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SUBSTRATE RELATIONSHIPS OF SOME BRYOPHYTE COMMUNITIES ON LATOUCHE ISLAND, ALASKA[1]

HANSFORD T. SHACKLETTE[2]

During the summer of 1957 the writer, while employed by the U. S. Geological Survey, spent the period July 13 to August 3 on Latouche Island, Prince William Sound, in biogeochemical exploration. This island is remarkable for having areas in which leafy liverworts form an almost continuous ground cover, sometimes to the exclusion of all other plant species. The prominence of a particular liverwort varies from area to area, from being the exclusive species present to being present only in small numbers. Because of these unique types of plant communities, a study was made of their areas and compositions. It is also of interest to observe the ecological amplitudes of species in substrate requirements or limitations in a climate so eminently suited to the growth of liverworts. The occurrence and composition of some liverwort communities of this island are believed to be related to the chemical nature of the substrate (*fig.* 1).

Latouche Island, one of the outermost islands in Prince William Sound, lying about 100 miles southwest of the mainland port of Valdez, is the former site of a large copper ore deposit which was mined before 1934 in the Beatson mine. Since then all mining has ceased, and there was only one permanent resident on the island at the time of this study.

The predominant rock types, believed to be of late Mesozoic age, are hard, compact, dull-gray graywacke and interbedded medium- to dark-gray slate (Stejer, 1956, p. 110-111). The primary copper mineral is chalcopyrite ($CuFeS_2$), which before being removed by

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[2] U. S. Geological Survey, Georgetown, Ky., and Dept. of Botany, University of Michigan, Ann Arbor.

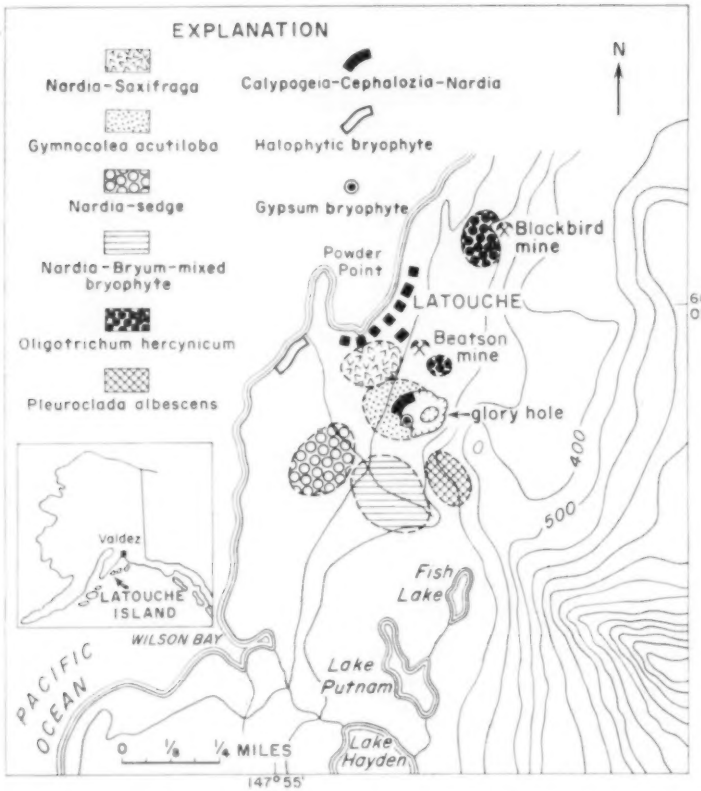

FIG. 1. Sketch map of the Latouche area, Latouche Island, Prince William Sound, Alaska, showing the location of some bryophyte communities. (Reference: U. S. Geol. Survey, Seward A-3 quadrangle, 1:63,360 series.)

mining formed a surface outcrop near the village of Latouche and which determined the site of the Beatson mine. The removal of the ore has left a large craterlike "glory hole" having a pool of water in it. This water is colored a medium blue by copper sulfate, as seen in a test tube, and has a pH value of 4.8 The only organism observed in this water was a filamentous alga which has been provisionally identified as *Stichococcus fluitans* Gay (Family Ulotrichaceae) by W. R. Taylor, Dept. of Botany, University of Michigan. On the island as a whole, according to Stejer (1956, p. 114), "Pyrite is by far the most abundant mineral, and in many places the massive sulfide is essentially pure pyrite. The copper-bearing minerals, cubanite and chalcopyrite, are about equally abundant

and commonly are very intricately intergrown. Small amounts of sphalerite and tiny grains of arsenopyrite and galena are widely distributed throughout the sulfide-bearing bodies." These massive bodies lie in the vicinity of Horseshoe Bay (not shown on the sketch map), about 2½ miles southwest of Latouche village, and are covered with a thick organic soil layer and dense vegetation. One outcrop was found near the Duke mine where a stream cuts into the sulfide body and exposes the pyrite ore to plant colonization. The shore lines at Powder Point and on Chicken Island (the latter lying in Latouche Channel about three-fourths mile west of Wilson Bay; not shown on the sketch map), where halophytic communities were observed have exposures of interbedded graywacke and dark-gray slate.

The climate is a mild, wet coastal type, characterized by heavy precipitation, many cloudy days, and frequent fogs. The mean annual precipitation of 184 inches gives this island next to the highest average recorded in Alaska. The local weather station reported a maximum annual precipitation of 248 inches in 1926. The average annual snowfall is about 153 inches. The mean annual temperature is about 42° F, with an absolute maximum of 82° and an absolute minimum of 1° above zero. One can reach the island by boat or float plane (there is no airstrip), but periods of foul weather often make the island inaccessible, either by air or sea, for several weeks at a time.

Latouche Island is near the northern and western limit of the coastal forests of western hemlock, mountain hemlock, and Sitka spruce. Much of the area around the mines has been disturbed by mining and other activities; however, revegetation is so fast, and the growth is often so rank that it is sometimes difficult to delimit precisely these areas at present. The plant communities farther inland from the coast are assumed to be approximately in their primitive condition. The striking feature of the particular sites to be considered first in this report (the sites near outcrops of copper mineralization) is the occurrence of a number of gaps in the normal vegetation where the ground cover is dark brown to black, giving a barren appearance to these parts of the landscape. These sites may vary from a few yards to 150 yards in diameter and are not always sharply defined at the boundaries but may grade into "normal" vegetation or other "barren" areas. The locations and limits of these "barren" areas, which are actually liverwort communities, are shown on the sketch map in a generalized fashion only intended to center around the most characteristic part of the particular community (*fig.* 1). These bryophyte communities, as well as some others, are briefly described; included also are notes on other plant

associates, and the edaphic conditions that prevail for each community.

Gymnocolea acutiloba Community

Adjacent to and extending downslope from the "glory hole" is a rather extensive area characterized by its dark-brown to almost black color and the almost total absence of any plant except the liverwort *Gymnocolea acutiloba* (Kaal.) K. M. The living plants form a thin layer on the substrate, which when dry (probably a rare occurrence, but observed during this visit) breaks up into "crusty" patches as much as 4 to 6 inches in diameter, having incurved edges. This substrate is a deposit as much as 18 to 24 inches deep of a fine-textured, friable organic matter so loose that the hand can easily be thrust into it to a depth of 8 to 10 inches. This resembles a fine grade of pulverized commercial peat except that it is lacking in fibrous elements. All evidence at hand indicates that this organic matter may properly be termed "liverwort peat"; the writer is not aware of prior descriptions of this type of deposit. It is rather uniform in vertical extent, has no pronounced profile characteristics except that it is somewhat more compacted at lower levels, and varies in depth with the degree of slope. The bottom portion, when broken up, is somewhat more powdery than near-surface material, probably owing to its more advanced stage of decomposition. It extends to bedrock, or to a coarsely fragmented and somewhat intermixed C zone of country rock. In the soil classification scheme used by Kellogg and Nygard (1951), this deposit perhaps comes closest to fitting a Half Bog soil, but lacks a gley zone and some other features of this soil type.

In explaining the occurrence of this community we must examine the known habitat requirements of this species of liverwort. Reynaud-Beauverie (1936, p. 165) may be quoted: "Spéciales au cuivre: quelques hépatiques, *Gymnocolea acutiloba, Cephaloziella* sp. etc. . . ." Müller (1951, p. 280-281) says, "Erst neuerdings wurde eine kleine Gruppe von Lebermoosen bekannt, die an den verschiedensten Stellen, oft in Gesellschaft, auf dem Schutt von Kupfer- oder Zinnbergwerken anzutreffen sind. Auf solche Böden wurden gefunden: *Gymnocolea acutiloba, Cephaloziella Massalongoi* und *C. phyllacantha*." Schatz (1955, p. 113) writes, "Copper ores are the principal or sole substrates for the hepatics *Cephaloziella phyllacantha, C. massalongii* and *Gymnocolea acutiloba*." Müller's earlier opinion (1906-11, p. 746) that we do not yet know enough about the distribution or habitat of *Gymnocolea acutiloba* because it has been so seldom found still holds true; he states that it was often associated with *Cephalozia bicuspidata* and

Marsupella emarginata and adds, "Auffallend ist das Vorkommen (in Salzburg und in Kleinasien) auf kupferhaltigem Boden!" From these authors we see that if this species is not an obligate copper-associated species, it can at least tolerate concentrations of this metal in its substrate that are inhibitory or lethal to most other plant species.

This particular Latouche Island site has through the years received drainage water from a rich copper outcrop, and in recent years undoubtedly has received salting of copper ore dust through mining and milling operations. The interpretation of this unique community must be based on this assumed copper influence, which has provided a concentration beyond the tolerance limits of other species of plants, or on the assumption that under this metallic concentration this liverwort has a competitive advantage over other equally tolerant species. The climate is very favorable for the growth of liverworts, and this species has apparently had little competition from other bryophyte species or from vascular plants; therefore it is now, and probably has been for a very long time, the sole occupant of this site. This can truly be termed an edaphic climax community.

Oligotrichum hercynicum Communities

The moss *Oligotrichum hercynicum* (Hedw.) Lam. & DC. is most commonly found on rather bare, newly-disturbed "mineral" soil and is, in the writer's experience in Alaska, a facultative associate with copper deposits; it is also found on sites of no apparent metallic enrichment. Two separate communities of this species, in which it was the sole occupant of the site, were observed. The first, near the portal of the Beatson mine adit, was growing on a pile of chalcopyrite-bearing rocks. The individual rock fragments varied from gravel to cobble size and were somewhat cemented by fine-particle-size material probably resulting from weathering. This colony was not more than 23 years old at the most, for it could not have existed in this place during mining operations. The exclusive occupancy by this moss may be explained by (1) its resistance to a high copper concentration and (2) the fact that the other species most likely to replace it (*Gymnocolea acutiloba*) could not endure the more nearly mesic substrate or had not yet had time to colonize it. The second colony of this moss was on the disturbed area in front of the Blackbird mine portal, on a substrate of mixed copper-bearing rocks and tailings that had been removed from the mine. The species was again fulfilling its role as primary invader of a "mineral" soil (Watson, 1955, p. 112); the succession of other

species of plants was undoubtedly delayed by the copper concentration in the soil, although some were beginning to encroach on this moss community from the periphery. Future plant succession on this site cannot be confidently predicted; probably a copper-resistant liverwort will invade and dominate the area until slow disintegration and leaching of the rather shallow copper-bearing overburden reduces the concentration of this metal to a level that vascular plants can tolerate.

Calypogeia-Cephalozia-Nardia Community

As a result of the extensive mining operations in this area, very few surface outcrops of the copper ore vein are left. A small chalcopyrite vein, with considerable intermixed slate, near the rim of the "glory hole" supported a small bryophyte community. These plants were surrounded by a greenish secondary copper mineral formed from the weathered chalcopyrite, an indication that the plants were growing in a very high mineral concentration. Three species of leafy liverworts comprised the community, as follows:

(1) *Calypogeia muelleriana* (Schiffn.) K. M. Regarding the edaphic environment of this species, Schuster (1949, p. 533) says, "The species has an apparently wide ecological amplitude and occurs from rather dry sites to bog holes." Later Schuster says (1953, p. 543) that its pH preference is unknown, but that it is reported, in part, from calcareous regions.

(2) *Cephalozia bicuspidata* (L.) Dum. Schuster (1953, p. 507) says of this species, "apparently no tolerance for even traces of lime . . . often with *Gymnocolea-C. bicuspidata* Associule." He says earlier (1949, p. 538-539), "This species occurs in our area almost exclusively as a mesohygrophyte, most abundantly and characteristically as a chasmophyte and over wet ledges, or on wet talus (either directly on rock-fragments, or on the clayey soil resulting from its disintegration), where it is obviously an initial invading species of the *Cephalozia bicuspidata-Calypogeia trichomanis-neesiana* Associule. . . . This species has only a slight lime tolerance but a considerable tolerance for direct sunlight if there is abundant water." The communities described in this paper are all in direct sunlight; however, the light here is not nearly as intense as that of New York State, where Schuster made this observation.

(3) *Nardia scalaris* (Schrad.) Gray. The writer agrees with Persson and Gjaerevoll (1957, p. 14) that this species is often a snow-bed species in Alaska; however, it is not by any means restricted to this habitat. Its principal requirements, in determining its habitat, appear to be abundant water and light and lack of com-

petition with other plant species. Watson (1955, p. 355) says, "This is a pronounced calcifuge species and is thus rare or absent in limestone districts." Observations of this species on Latouche Island suggest that it is the most vigorous of the leafy liverworts of this region, and is the last species to retain a foothold among invading vascular species.

The occurrence of this group of liverworts on a substrate so concentrated in copper content demonstrates the high tolerance of these species for this metal or for other conditions associated with the occurrence of the ore. They are not obligate cuprophilic plants.

Pleuroclada albescens Community

In an area lying southeast of the "glory hole" toward the ridge leading up to Mount Beatson (altitude, 2065 ft.; just east of the sketch map) are a series of low terraces in front of the more abrupt declivity where the country rock crops out. Extending over parts of two of these terraces is an area in which the surface is covered by a dark organic material supporting an almost unbroken carpet of the liverwort *Pleuroclada albescens* (Hook.) Spr. Associated with it, however, was copper bush (*Cladothamnus pyrolaeflorus* Bong.), deer cabbage (*Fauria crista-galli* (Menz.) Makino), and a sparse growth of grasses and sedges too immature at this time to identify. This assemblage of vascular plant species and their condition of growth indicated at once that this was a snow-bed community. The liverwort, moreover, is considered by the writer to be a snow-bed species because of its observed occurrence in Alaska. This also agrees with Müller's interpretation (1951, p. 280). The reason for the occurrence of this liverwort species at this site, rather than the well-known snow-bed species *Nardia scalaris*, is a matter of conjecture. Probably sulfide deposit outcrops or disseminated sulfides in the ridge back of this site are contributing copper to the drainage entering this community. *Pleuroclada albescens*, judging from its known occurrence on mineralized deposits on Yakobi Island and in the Alaska Range, is assumed to have a certain degree of tolerance for copper, but this is also true of *Nardia scalaris*.

Nardia-Bryum-Mixed Bryophyte Community

Lying adjacent to and extending to the southwest of the *Pleuroclada albescens* community is a larger area occupied almost exclusively by bryophytes. The ground surface has a dark, "barren" appearance, but a rougher texture than has the pure liverwort community described first in this report. The most conspicuous

components, because of their abundance or size, are *Nardia scalaris* and *Bryum inclinatum* (Web. & Mohr) Sturm, although there is an irregular admixture of *Oligotrichum hercynicum* and *Gymnocolea acutiloba*, with occasional other species. This species of *Nardia* appears to be the most vigorous of all the leafy liverworts encountered in Alaska where environments are favorable for it, and it appears to be highly competitive with the other species on most substrates. The location of this community and its composition of species suggests that it is receiving a "halo" effect from the copper deposits, as there is prior evidence that all these species, with the exception of the *Bryum* which is classified by Amann (1912, p. 206) as "indifférent," are copper resistant. It is believed that the copper concentration is sufficiently low to permit these species to grow here, yet high enough to prevent other bryophytes and vascular plants from invading the community. This community is on an organic peat-like soil, somewhat similar to the "liverwort peat" described above, but neither as deep nor as uniform and fine in texture as the latter. The community gives evidence of considerable age and stability. The invasion of grasses and sedges at the boundaries appears to be controlled by the unfavorable edaphic conditions—possibly copper content. No trees or shrubs are entering the area.

Nardia-Sedge Community

A rather large area more remote from the ore deposits than those already described and centered on the broad, flat terrace leading to the coastal cliffs has a sedge meadow developed on it with a ground cover of *Nardia scalaris* broken only by the sedge tussocks. These tussocks are usually separated 4 to 8 inches from each other, possibly because of cryopedological processes; the reddish-brown peaty soil between them is covered with this liverwort, which also threads through some of the sedge clumps. There are several species of the sedge genus *Carex* present (*C. kelloggii* Boot, *C. canescens* L., *C. macrochaeta* C. A. Meyer, *C. pauciflora* Lightf., and *C. sitchensis* Prescott), which comprise at least 80% of the vascular plant cover, as well as cotton grass (*Eriophorum gracile* Koch) and bur-reed (*Sparganium angustifolium* Mx.). Forbs occur only rarely, mostly as individual plants—notably, the very fragrant "wild hyacinth" (*Platanthera dilatata* (Pursh) Lindl.).

This community appears to be completely removed from the influence of the ore outcrop. Its development as a sedge meadow results from its low relief, the drainage from the ridge back of it, and the heavy precipitation of the region. This vigorous liverwort species is able to occupy a niche in this community, which as a

whole has become rather static. Higher slopes at either side of this meadow and occasional slight ridges or mounds in it are occupied by rather depauperate specimens of dwarf blueberry (*Vaccinium uliginosum* L.), yellow heather (*Phyllodoce glanduliflora* (Hook.) Cov.), and copper bush, with a few mountain hemlock (*Tsuga mertensiana* (Bong.) Sarg.), western hemlock (*T. heterophylla* (Raf.) Sarg.), and Sitka spruce (*Picea sitchensis* (Bong.) Carr.). If we wish to use climax terminology, we may designate this community a physiographic climax, as it appears to have existed in this stable condition for a long time and only upon this terrain site.

Nardia-Saxifraga Community

A community consisting almost exclusively of *Nardia scalaris* and *Saxifraga ferruginea* Graham occurs in the greatly disturbed area between the Beatson mine portal and the village of Latouche, and in all the vacant spaces between the buildings and walks of the village. The liverwort has formed an organic crust about one-half inch thick, and the saxifrage is rooted in this crust so densely that its wide-spreading inflorescences commonly form an almost unbroken thin cover. The substrate everywhere has undoubtedly been heavily salted by dust and drainage from the large ore mill just above it and from the piles of ore and tailings about the portal and ore cars. Apparently this young community has been established by two vigorously reproducing species having high resistance to copper. Samples of the substrate were analyzed for copper and found to have various, but always high amounts; this was as expected, for one could not be certain whether it was "soil" or ore that he was sampling. This community will probably persist until leaching of the rather shallow ore-enriched surface has reduced the copper content to the tolerance level of other plant species. In an area of such heavy precipitation this may not require many years.

The bryophyte communities having a definite or inferred relation to copper deposits have now been presented, and we turn our attention to some other communities of interest because their substrate content of elements is anomalous in relation to the normal tolerance or requirements of most liverworts. These communities are related to the occurrence of gypsum, pyrite, and the salts of ocean water.

Gypsum Bryophyte Community

Well within the "glory hole," about half way from the rim to the bottom is a water seep from black slate bedrock. The seep and the water path below it are heavily coated with gypsum ($CaSO_4 \cdot 2H_2O$)

which has precipitated out of the water and formed incrustations on the thick cushions of bryophytes that surround the seep and drain. The most conspicuous of these are the mosses *Dicranella subulata* (Hedw.) Schimp. and *D. cerviculata* (Hedw.) Schimp. Two liverworts also occur in abundance, *Cephalozia bicuspidata* and *Lophozia wenzelii* (N.) St. Our knowledge of the edaphic requirements or tolerances of these bryophytes is very incomplete. *Dicranella subulata,* in its Alaskan distribution, occurs on a wide variety of substrates. *Dicranella cerviculata* was found at only one other locality by the writer, and so generalizations cannot be made concerning its requirements. Amann (1912, p. 48) describes this species, "Xerophile et mesophile. Turficole. Calcifuge." *Lophozia wenzelii* has been found on amphibolite schist, slate, and probably other substrates. *Cephalozia bicuspidata,* discussed earlier in this report, is a very widespread species and is noted for the great variety of substrates which it occupies. The varying substrates, or other ecological conditions relating to site, may cause great morphological variations in this species which has led to the naming of numerous varieties and forms. The occurrence of this community of such limited extent does not warrant a statement concerning the gypsum tolerance of the many other bryophytes of this island which could, theoretically, have occupied this site. It can only be stated that these four species can tolerate saturated solutions of calcium sulfate, and that under these conditions their growth rate is still sufficient to exceed the rate of mineral precipitation, so that a small tufa-like deposit is formed around the seep. Gypsophilous bryophytes are discussed by Amann (1928, p. 101) as follows: "Les terrains et roches gypseux présentent, comme je l'ai dit plus haut, une végétation bryologique peu différente de celle des supports calcaires. Nous ne connaissons, en fait d'espèces que l'on pourrait qualifier de gypsophiles, que le *Tortula Fiorii,* qui doit, du reste, être considéré, du point de vue biologique, comme une *sélénitomorphose* du *T. atrovirens.* Il en est de même des formes et variétés, spéciales aux terrains gypseux, de certain espèces communes (et du reste indifférentes sous le rapport édaphique), telles que *Tortula muralis* fo. *gypsophila, Tortella inclinata* fo., *Bryum argenteum* var. *gypsophilum, Hypnum cupressiforme* fo., etc. Ces mousses croissant sur les roches gypseuses, sont soumises à l'action de solutions aqueuses saturées de gypse, qui, souvent, se sépare et cristallise à la surface et à la pointe des feuilles."

Pyrite Bryophyte Community

The pyrite (FeS_2) outcrop near the Duke mine mentioned earlier has a very small surface exposed to plant colonization—

nevertheless, five species of bryophytes occur on it, as follows: *Rhacomitrium fasciculare* (Hedw.) Brid., *Oligotrichum aligerum* Mitt., *O. hercynicum, Drepanocladus uncinatus* (Hedw.) Warnst. (all mosses), and the liverwort *Nardia scalaris*. All these species are able to grow on a variety of substrates, and although they are not at all obligate sulfide species, yet by this occurrence are shown to be facultative species for pyrite in a very pure form. Where the pyrite body extends below the surface of the stream that cuts through this deposit a moss (*Dichodontium pellucidum* (Hedw.) Schimp.) and a liverwort (*Scapania undulata* (L). Dum.) were growing submerged in about six inches of water, attached to the pyrite and to graywacke. The requirements of the moss are said by Amann (1912, p. 42) to be "hydrophile et hygrophile; sciaphile. Saxicole et arénicole. Calcifuge préférant." The liverwort grows on a wide variety of substrates. Although these plants are attached to pyrite, the total mineral content of the swift stream undoubtedly masks substrate influence on them.

Halophyte Bryophyte Community

The plant communities along most of the shore line of Latouche Island are of necessity composed of chasmophytes, for the shores consist of bedrock (often vertical cliffs) except in some bays where the great tidal fluctuation of this region has developed rather small tidal flats and areas of brackish pools. Moss communities are not prominent features of these littoral regions. Richards (1932, p. 384) says, "Mosses in general strongly avoid salt water. None live in the sea and few can be called true halophytes. A certain number are salt-tolerant, growing in places where they are liable to be covered by the tide or by spray, as well as inland, e.g. *Tortella flavovirens, Pottia Heimii, Camptothecium sericeum, Hypnum cupressiforme*. There are extremely few obligate halophytes. *Grimmia maritima* is confined to rocks just above high tide mark . . . on the coasts of the North Atlantic. It is often covered with salt spray and never grows in inland habitats. . . . Various mosses such as *Glyphomitrium Daviesii* and *Ulota phyllantha*, which very rarely occur except on maritime rocks, may perhaps be halophilous to some extent." Chapman (1960, p. 183-184), in discussing the reports of salt marsh vegetation of Spitsbergen, says "The primary phanerogam colonist, which advances seawards through the growth of stolons, is *Puccinellia phryganodes*. Associated with it are species of *Enteromorpha* and the moss *Swartzia inclinata* together with the moss *Bryum nitidulum*. These Spitsbergen marshes, as also those of Finmark, are therefore remarkable for the presence of

mosses that must be capable of tolerating some submergence by the sea. It is likely, however, that following the snow-melt, conditions are brackish during much of the growing season." The present writer has collected the moss *Swartzia inclinata* (= *Distichium inclinatum* (Hedw.) BSG) in the Alaska Range, where at one site it was a tufa-forming species, but did not find it in coastal districts of the state.

Very little has been found in the literature concerning salt tolerance of the liverworts. Müller (1951, p. 281) states, "Nur Arten der Gattung *Riella* können ausser auf schlammigem Boden am Rande von Süsswasserseen auch an schwach brackigen Stellen am Meeresufer gedeihen. In Ungarn wurden an salzhaltigen Plätzen gelegentlich auch *Marchantia polymorpha,* und *Riccia glauca, crystallina, cilustra, ciliata, sorocarpa* und *Frostii* beobachtet, im Mediterrangebiet auch *Petalophyllum* und *Oxymitra.* Alle anderen Lebermoose meiden solche Stellen."

The bryophyte species subjected to salt water at this location may be divided into two groups—those that are at or slightly below the ordinary high-tide level and are therefore regularly bathed in sea water, and those above the tide level and therefore only occasionally covered by waves or spray. The first group includes the well-known maritime moss species, *Grimmia maritima* Turn., as well as *Eurhynchium praelongum* (Hedw.) Hobk., *Mnium glabrescens* Kindb., and the liverwort *Scapania undulata* (L.) Dum. All species in this group were growing in crevices of slate or graywacke and were actually seen to be submerged by high tide. This report of *Scapania undulata* may be the first to indicate that any species of leafy liverwort is a facultative halophyte. Species growing on rocks near salt water but beyond direct wave or tide action were the mosses *Arctoa fulvella* (Dicks.) B. & S. (which also grew on tree trunks), *Pogonatum capillare* (Mx.) Brid., *Hypnum circinale Hook.*, and *Bryum inclinatum* (Web. & Mohr) Sturm. The moss *Pohlia nutans* (Hedw.) Lindb. was seen quite often growing on driftwood on the shore. *Ulota phyllantha* Brid. was found growing on the branches of alder bushes (*Alnus crispa* ssp. *sinuata* (Regel.) Hult.) on cliffs just above the sea. This species of *Ulota* is a common maritime moss in Europe, frequently found on rocks with *Grimmia maritima.* It was likewise found on maritime rocks with this same *Grimmia* species on Yakobi Island, southeastern Alaska. At Mahoney Creek, Revillagigedo Island, southeastern Alaska, this *Ulota* grew on Sitka spruce branches on the sea coast. Barkman (1958, pp. 98-99) suggests an explanation of this alternation of habitats of *Ulota* on the basis of the proportions of antagonistic ions, as follows: "It is a well-known fact that the proportion

of concentrations of antagonistic ions have a great influence upon permeability of the protoplasmic membrane and consequently upon the whole nutrition mechanism of plants generally. The proportion of mono- and bivalent kations (a) is of particular importance, secondly the proportion of $K\cdot$ and $Na\cdot$ (b). Unfortunately (a) cannot be calculated for epiphytes, as the actual concentrations of dissolved Ca and Mg in wet bark are not known exactly. Therefore, only the K/Na proportion has been calculated. The weight ratio of their oxides proves to be extremely high (no sodium found) in *Acer platanoides, A. campestre, Juglans regia,* and *Fagus silvatica,* 190.0 in *Prunus mahaleb,* 27.0-38.0 in *Abies,* 14.0 in *Sambucus nigra,* 8.5 in *Fraxinus,* 2.0-7.0 in *Picea,* 2.9 in *Tilia,* 0.5 in *Prunus avium,* and .02 in *Ulmus.* There is no correlation whatever with epiphytic vegetation, except with regard to *Ulmus campestris* which has the lowest ratio, and is rich in sodium. Now, this is almost the only tree on which *Ulota phyllantha* is found in the Netherlands. This very moss is also the only epiphytic bryophyte, that equally occurs on coastal rocks affected by spray. Of all trees examined *Ulmus campestris* approaches that habit most nearly with regard to K_2O/Na_2O proportion, being 0.0317 in sea water."

Discussion and Summary

Concerning the general relationships of bryophytes to their substrate Richards (1932, p. 381) says, "The response of bryophytes to edaphic factors is certainly sharper and clearer than that of flowering plants." In speaking of the requirements of liverworts Schuster (1949, p. 647) states, "Chemical composition of the substratum is of great importance in delimiting the nature of the hepatic flora. The individual effects of the various important elements have not been studied to any degree." He suggests the division of these plants into three groups: species of calcareous rocks, species of sedimentary rocks neither distinctly calcareous or acidic, and species of siliceous rocks. These same three general categories have been recognized by many writers under slightly different names. As Richards points out (1932, p. 383), these categories must be used with care because habitat conditions may be deceiving; the organic deposit rather than the type of rock beneath it may be the determining factor. The excellent discussion of "copper mosses" by Persson (1956) leaves little to be said in regard to these plants, and a selected literature list is given by him. In respect to the effects of various toxic substances on mosses, Amann (1928, pp. 102-103) may be quoted as follows: "Il est naturel que la présence, dans un substrate, de certain composés toxiques, exclut la végétation des

mousses; c'est la cas, p. ex., pour les sels de barium, les terrains pyriteux à réaction acide, les eaux sulfureuses, cuprifères, etc., les terrains trop alcalins par la présence de carbonate sodique, etc. Ici aussi, la tolérance et la phobie diffèrent selon les espèces. On peut indiquer comme ayant une certain importance pratique, l'action nuisible pour les mousses de la fumure au moyen des engrais azotés, des sels solubles du fer (sulfate), ainsi que la chaulage du sol et des arbres, procédés employés pour se débarrasser des mousses et des lichens."

Several bryophyte species are shown in this paper to have the ability to maintain themselves as the sole occupants of an unusual substrate or to share this site with other bryophyte species presumed to have somewhat similar tolerance. As to their competition with the higher plants for site occupancy, Richards (1932, p. 393) says, "Owing to their small size and restricted growth mosses are always at a great disadvantage in competition with vascular plants and it is roughly true to say that any factor which checks the growth of herbaceous plants favors moss vegetation." It appears that the exclusive bryophyte communities described in this report are freed from the competition of vascular plants by their tolerance of a copper concentration which is lethal to the latter. The liverwort *Gymnocolea acutiloba* may possibly be an obligate cuprophile, as suggested in the literature; the writer has collected it in Alaska only from copper-containing substrates and only on Latouche Island.

The paper by Schatz (1955) and the one by Persson (1956) raise the question as to the exact factor of the substrate that regulates the occurrence of the "copper mosses" (this term is, for convenience, used to include the liverworts as well). Some of the characteristic plants of this category also occur on ores of zinc, iron, and lead, as well as at sulfur springs. Schatz points out that these ores exist as sulfides of the metals in question, and that these bryophytes might be more properly designated "sulfur mosses." He presents a very interesting further development of this hypothesis, which will not be reviewed here, except to state that he postulates reduced sulfur to be the required element of these species. In this connection one should note that the three different types of substrates on Latouche Island which supported "copper moss" species in common were all sulfur-containing compounds—sulfide of copper and iron, hydrous calcium sulfate, and iron sulfide. It is regrettable that more quantitative measurements of these interesting substrates could not be made, because of the limited time available for this phase of the geochemical study.

The characteristic dark-brown to black areas of coastal Alaska often represent predominantly leafy liverwort communities. They are very conspicuous when seen from a plane or helicopter, and usually indicate only that the area is the site of a snow bed. Particularly during the first to the middle of June they form an aspect dominant community on the mountainous islands of this part of Alaska. Their occurrence as an indication of an anomalous geochemical condition, such as obtains on Latouche Island, is presumed to be rare, inasmuch as exposed mineral outcrops are also rare. Aerial views of the landscape in late summer might differentiate the two classes of liverwort "barrens," for in most of the snow beds vascular plants would have assumed aspect dominance by this time, whereas the metal-controlled liverwort communities would present much the same barren, black aspect of the liverworts as seen earlier, because the vascular plants are totally excluded or severely reduced in prominence by the metal concentration in the substrate.

Several mosses and a liverwort were determined, possibly for the first time, to be facultative halophytes. Their occurrence on this island under these conditions was no doubt encouraged by the other ecological factors here unusually favorable for bryophytes (especially leafy liverworts)—moisture, temperature, and light—which permit them to express their full range of edaphic amplitude in respect to tolerance for an abnormal concentration of a particular chemical. None of these halophytes showed salt incrustations on their leaves, an indication that the unusually heavy and frequent precipitation may often wash off or dilute the salt solution. In such a cool, humid environment evaporation from the surfaces of the bryophytes is at a minimum; therefore the cells of the plants are spared the concentrating effect of evaporation on the salt solution. In effect, these plants are subjected to no greater salt concentration than that of ocean water; in hotter, drier climates, exposure at low tide to the salt-concentrating effect of evaporation may result in death of the plants from plasmolysis. The climate in this region of Alaska is therefore thought to be a compensating factor in apparent salt tolerance, and the prominence of halophytic mosses in Spitsbergen as mentioned earlier may be, at least in part, an expression of the same climatic relationship.

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ON ACROMASTIGUM IN SOUTH AMERICA, WITH COMMENTS ON THE PATAGONIAN BAZZANIAE

RICLEF GROLLE[1]

In his monograph on *Acromastigum* (1934), Evans recognized three South American species: *A. anisostomum* (Lehm.) Evans, *A. lactevirens* (Sde.-Lac.) Evans, and *A. cunninghamii* (St.) Evans. He noted further that a Patagonian specimen reported by

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Schiffner (1889) as the Indomalayan *Mastigobryum divaricatum* (Nees) G. L. & N., although too scanty for certain determination, might belong instead to *Acromastigum colensoanum* (St.) Evans, a species of New Zealand. In 1957 S. Arnell described an additional species from Juan Fernández, *A. fernandeziense*.

A. ANISOSTOMUM: Among the South American species of *Acromastigum*, *A. anisostomum* is relatively well known. Its perianth was illustrated by Lindenberg and Gottsche as early as 1851, but its androecia are still unknown. The species occurs in Auckland (!) and New Zealand (!) and in western Patagonia from the Brecknock Peninsula (Massalongo, 1885) northward to Chiloé (!); it seems to be absent from the eastern portion of the tip of South America (the Falkland and States Islands and eastern Tierra del Fuego). Australian and Tasmanian records in the literature are uncertain because, according to Hodgson (1954), *A. mooreanum* (St.) Hodgs. is distinct, but past records of *A. anisostomum* from those areas may include *A. mooreanum* as well.

A. CUNNINGHAMII: Although he had access to specimens from only two localities, Evans (1934) furnished an excellent description and illustrations of *A. cunninghamii*. His key for the separation of that species from its relatives, *A. curtilobum*, *A. colensoanum*, and *A. laetevirens*, is less successful, since the characters given in couplet 11 are not comparable and therefore do not make possible any distinction. Herzog (1954), as a result, reported, with illustrations, several specimens of *A. laetevirens* as *A. cunninghamii*, although he noted that the plants did not entirely agree with Evans' description. Obviously for the same reason, a specimen of *A. laetevirens* in herb. Stockholm was misnamed *A. cunninghamii* by S. Arnell. *A. laetevirens* and *A. cunninghamii* are, however, clearly distinct, as shown by the key and the figures included in the present paper.

I have little to add to Evans' description of *A. cunninghamii*: The cuticle on the leaf cells is not always smooth. I found young archegonial inflorescences on short, ventral-intercalary branches; they have four to five abruptly enlarged whorls of leaves. The involucral bracts are free and divided one-third to one-half way down into two long-acuminate laciniae. The leaf margin is somewhat toothed because of projecting cells. The perianths were not yet mature, since the 2 or so archegonia had not yet been fertilized.

Specimens examined. WEST PATAGONIA: Port Hale, Canal Messier, *C. Skottsberg*, in 1908 (UPS, as *A. cunninghamii*; also UPS, as *A. laetevirens*); Guaitecas I., *P. Dusén* (S and UPS, with *A. anisostomum*).

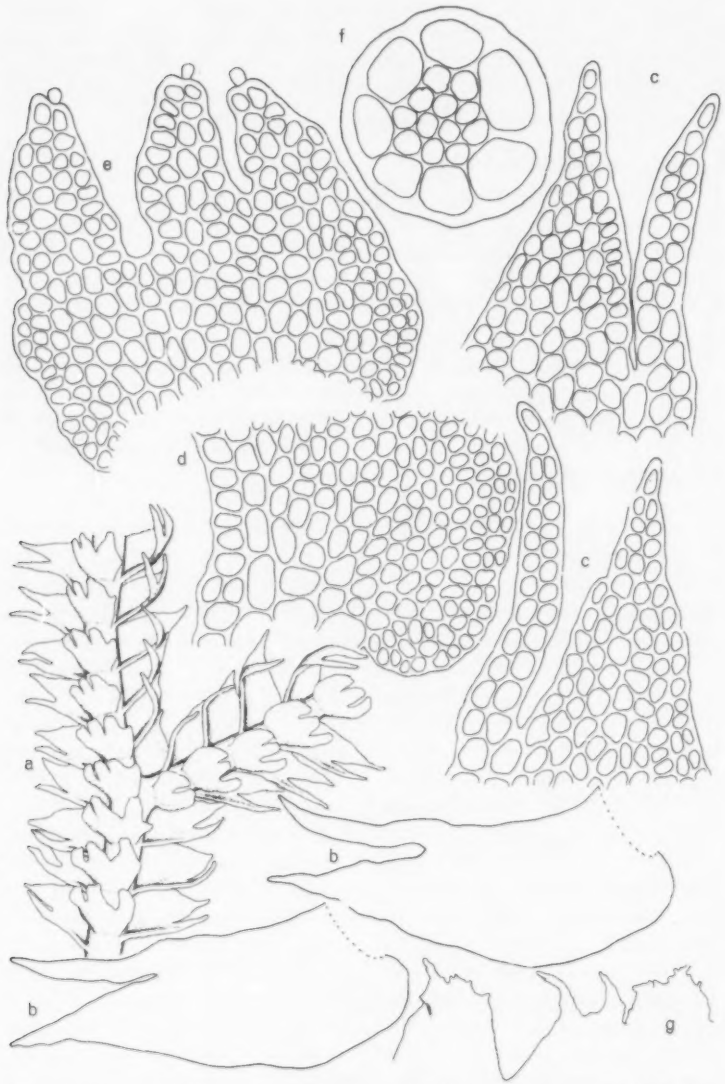

FIG. 1. *Acromastigum cunninghamii*. *a*. Portion of stem in ventral view, × 29. *b*. Leaves, × 62. *c*. Leaf apices, × 125. *d*. Leaf base, × 125. *e*. An amphigastrium, × 125. *f*. Stem cross-section, × 125. *g*. Mouth of perianth, spread out, × 29. (All drawn from plants from Guaitecas, collected by Dusén.)

Stephani's report (1911) of *A. laetevirens* from Hale Cove (based on the second specimen cited above) belongs to *A. cunninghamii* instead; conversely, Herzog's record (1954) of *A. cunninghamii* should be referred to *A. laetevirens*. *A. cunninghamii* is known otherwise only from Halt Bay and Gray Harbor. Both Stephani and Evans erroneously assumed Gray Harbor to be on the Straits of Magellan, but it actually lies on the Canal Messier, at 48° 57′ S. I have been unable to find Halt Bay in any atlas; I imagine it is a misreading for Hale Bay, which is also on Canal Messier. Accordingly, *A. cunninghamii* has the most restricted area of distribution of any of the South American species of the genus (49°-43° 45′ S.).

A. LAETEVIRENS: There has been some confusion in the author citation for *A. laetevirens*. Stephani (1886) first published it as *Mastigobryum laetevirens* Sde.-Lac. n.sp., and in 1893 he mentioned it as *Bazzania laetevirens* Sde.-Lac. In his *Species Hepaticarum* (1909) and in a later publication (1911), he attributed the species, without comment, to Ångström (as "*Mastigobryum laetevirens* Ångström in Steph., Hedwigia 1886"). Unfortunately Evans (1934) followed Stephani's later version. According to current views on nomenclature, the authority given in the original publication, namely Sande Lacoste, should be used.

Both Stephani and Evans based their descriptions of *A. laetevirens* solely on the original specimen. On studying numerous collections, some of them quite abundant, from ten localities, I found that the strongly decurved leaves of the original plants, demonstrable even in the moist condition, are not characteristic. The leaves are usually almost planodistichous when moist. I could demonstrate, however, a complete intergradation from planodistichous to decurved leaves and thereby firmly establish the relationship of these plants which agree so well in other respects. The posture of the leaves was emphasized by Stephani in his remarks following the original diagnosis. Evans was unable to de-emphasize this character, inasmuch as his knowledge of the species was based on a single stem (from the type) seven millimeters in length. Except for *A. exile* (Lindenb.) Evans, *A. laetevirens* is the only one of the 34 species of *Acromastigum* treated by Evans (1934) which he did not illustrate. Stephani (1886), however, accurately illustrated the type, and Herzog (1954) provided figures of *A. laetevirens* (as *A. cunninghamii*, as mentioned above). A redescription of the species follows:

FIG. 2. *Acromastigum laetevirens*. *a*. Portion of stem, with perianth, × 11. *b*. Portion of stem in ventral view, × 29. *c*. A whorl of involucral bracts, × 15. *d*. Perianth mouth, × 29. *e*. Lobe from perianth mouth, × 187. *f*. Inner wall of capsule, × 187. *g*. Outer wall of capsule, × 187. (*b*. from the type, all others from *Schwabe 26*.)

ACROMASTIGUM LAETEVIRENS (Sde.-Lac.) Evans, Ann. Bryol. Suppl. 3: 94. 1934. *Mastigobryum laetevirens* Sde.-Lac. *in* St., Hedwigia 25: 133. 1886. *Bazzania laetevirens* (Sde.-Lac.) St., *Ibid.* 32: 206. 1893. *Acromastigum cunninghamii sensu* Herz., Rev. Bryol. et Lichén. 23: 49. 1954, *non* (St.) Evans.—Plants dioicous, up to 2 cm. long, pale to intensely green, mostly growing singly over or among other bryophytes, but sometimes in thin, lax, strongly interwoven mats. Main axis 0.14-0.20 mm. thick, distantly dichotomous because of terminal-lateral branching; flagella numerous as terminal-ventral or intercalary-ventral branches or produced by the gradual tapering of normal dorsiventrally foliate shoots; cortical

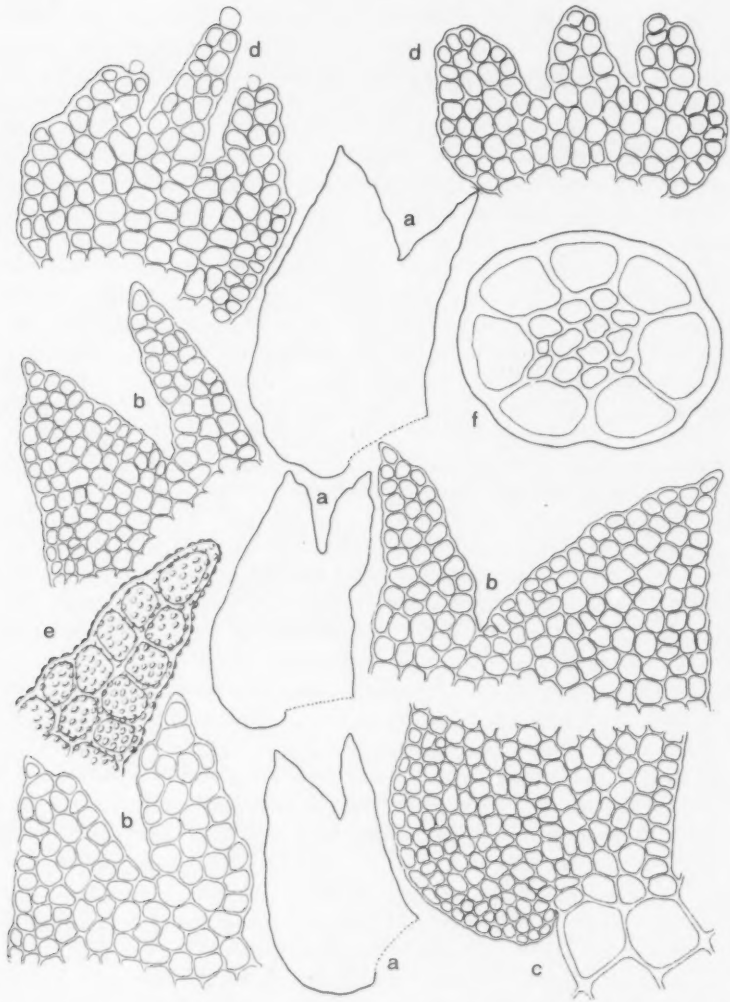

FIG. 3. *Acromastigum lactevirens* (continued). *a*. Leaves, × 62. *b*. Leaf apices, × 125. *c*. Leaf base, × 125. *d*. Amphigastria, × 125. *e*. Tip of a leaf lobe, × 303. *f*. Stem cross-section, × 187. (All drawn from *Schwabe 26*.)

cells subquadrate, large, 45-55 × 50-65 μ, with longitudinal walls 7-9 μ thick; stem cross-section showing 7 large cortical cells (3 ventral and 2 on either side) and 12-14 much smaller medullary

cells; all cell walls unpigmented and clearly incrassate, those of the cortex substantially thicker.

Leaves usually slightly overlapping, or sometimes more crowded (as in the type), or not infrequently rather remote, spreading at right angles or directed slightly forward (at 70-90°), ± decurved at the tips when dry but scarcely decurved when moist (or rarely so, as in the type) but planodistichous instead, slightly incubous from a straight insertion; leaves ovate, 1.5: 1, the ventral margin straight at the base, often somewhat precurved at the attachment of the ventral lobe, the dorsal margin strongly curved at base and the leaf base in this way dorsally narrowed, 1/3-bilobed at apex, with an acute sinus, both lobes moderately acute, the dorsal one (6)7(8) cells broad at base, the ventral one usually somewhat longer and 3(4) cells broad at base, the dorsal portion of the leaf rather flat, the ventral portion ± concave (as seen from the ventral side). Often the ventral margin is directed toward the observer (in ventral view) along its entire length or only at the base, whereas the leaves on delicate branches tend to be almost entirely flat.

Leaf cells with unpigmented walls, somewhat incrassate throughout and somewhat thickened at the corners but not trigonous; cuticle toward the leaf tips clearly papillose; cells in ± regular longitudinal and oblique rows, 25-30 μ in the middle and apical portions of the leaves, somewhat smaller in the dorsal-basal portion and larger in the ventral-basal portion; dorsal cell walls substantially thicker than the ventral walls, especially in the ventral-basal part of the leaves.

Amphigastria on well-developed plants clearly wider than the stem, 1½ times as broad as long, usually divided 2/5 down into 3 rather blunt lobes with acute sinuses, somewhat convex (as seen from the ventral side), rounded-precurved at the sides, the line of insertion straight across.

Involucres on very short, ventral-intercalary branches, often several borne in succession in the axils of adjacent amphigastria; bracts usually in 3 whorls, abruptly increasing in size, free, 1/3-bilobed, crenulate to weakly toothed. Perianth long-exserted beyond the involucral bracts, cylindric in the lower 1/3, deeply 3-plicate above, up to 6-plicate below the mouth which has 6 acute, crenulate to weakly dentate lobes; cells at the mouth somewhat elongate.

(The setae unfortunately were collapsed.)

Capsule wall ca. 35 μ thick, consisting of 2 layers (!) of nearly equal thickness, the outer layer with large cells with weakly thickened and slightly nodose radial walls, the inner layer with small

cells and mostly 1, or rarely 2 U-shaped thickenings (usually transverse, but sometimes oblique and rarely longitudinal).

(Such spores as were available had already germinated to form young plants of about 10 cells.) Elaters bispiral, slightly tapered, rounded at the ends, ca. 16 μ thick.

Vegetative reproduction obviously very pronounced: The older lateral leaves regularly break off shortly above the base so that the branches are often denuded of lateral leaves for considerable distances. Not infrequently only the lobes break off. The amphigastria are also somewhat fragile.

Specimens examined. TIERRA DEL FUEGO: "Fuegia," *Halle* (*in herb.* Grolle); Estero Staples, *Roivainen* (S, as *A. cunninghamii*). WEST PATAGONIA: Molyneux Sound, *Dusén* (S. sub *A. anisostomum*); Skyring, Estero Excelsior, in silva humida, *Halle* & *Skottsberg*, in 1908 (S); Terr. Aysén, Istmo de Ofqui, *Grosse 2*, in 1938 (*in herb.* Herzog); Pto. Puyuhuapi, Talwald, an Chila, *Schwabe* 9, in 1939 (*in herb.* Herzog). CHILE: Termas de Puyehue, Prov. Llanquihue, *Schwabe* 112, in 1940 (*in herb.* Herzog); Huitrapulli-Aleucapi, Valdivia, Aufstieg vom Moor, 600-700 m., *Schwabe* 13, in 1958 (*in herb.* Herzog); R. Chaihuin-Colun, Alerzal, Valdivia, ca. 500 m., *Schwabe* 26g, in 1958 (*in herb.* Herzog); Corral, Valdivia, *Krause* (S, portion of holotype of *M. laetevirens*).

Acromastigum laetevirens has the widest range of distribution in Patagonia of any member of the genus; it ranges from Tierra del Fuego far northward to 40° S.

There should be no great difficulty in distinguishing *A. laetevirens* and *A. cunninghamii* on the basis of characters given in the key and in the illustrations. It is not so easy, however, to differentiate *A. laetevirens* from *A. colensoanum* (St.) Evans and *A. divaricatum* (Nees) Evans. The basionym, *Jungermannia divaricata* Nees (Hep. Jav. 60. 1830), is a later homonym of *J. divaricata* Sm. (Eng. Bot. 10: 419. 1800)—a *Cephaloziella*. Therefore the author citation must be changed to *A. divaricatum* (G. L. & N.) Evans, for which *Mastiobryum divaricatum* G. L. & N. (Syn. Hep. 219. 1845) is the basionym.

Acromastigum divaricatum is distinguished from *A. laetevirens* by essentially narrower lateral leaves, distinctly longer ventral leaf lobes, and, above all, amphigastria scarcely as broad as the stem and without rounded-precurved lateral margins. In *A. laetevirens* the amphigastria on robust stems are broader than the stems and have rounded-precurved lateral margins. *A. colensoanum* is clearly differentiated by its stem cross-section which shows a cortex of more than seven layers of cells. Both *A. divaricatum* and *A. colensoanum* are, moreover, completely isolated geographically from *A. laetevirens*.

Schiffner's citation (1889) of *A. divaricatum* (as *Mastigobryum divaricatum*) from Patagonia (Straits of Magellan) is still unexplained. Evans believed, on the basis of a scanty specimen, that the record might be referred to *A. colensoanum* but emphasized that the specimen was too poor for a satisfactory decision. In view of the close similarity of *A. divaricatum* and *A. colensoanum* to *A. laetevirens*, it seems most likely that Schiffner's record belongs to *A. laetevirens* (which I have seen from the area in question).

Up to now *A. anisostomum* was the only member of the genus for which the capsule was known. Evans (1934) found it to have a 4-layered capsule wall. It is particularly interesting to note, therefore, that *A. laetevirens* differs in having a 2-layered capsule wall, as described above.

Also, as a contribution to our knowledge of the genus, I might mention that I have been able to ascertain that the antheridial stalk of *A. echinatiforme* (DeNot.) Evans has two rows of cells. This was not previously known for any species of *Acromastigum*. The antheridial wall cells are normal in size and not notably large as in *Telaranea* and *Arachniopsis*.

Key to the South American Species of Acromastigum

Cell walls always brown (especially in the stem), imparting a brown color to the whole plant; ventral leaf-lobes clearly longer than the dorsal; leaf cells uniformly very thick-walled, with clearly nodose thickenings only in the median-basal portions of the leaf; longitudinal walls of cortical cells 10-15 μ thick; amphigastria at most only as broad as the stem, twice as broad as long.....*A. anisostomum*

Cell walls pale, the plants bright green or becoming pale green; ventral leaf-lobes only slightly longer than the dorsal, or equal to them in length; cells in the median-basal portion of leaf not differing in thickening from other leaf cells; longitudinal walls of the cortical cells at most 9 μ thick; amphigastria mostly broader than the stem, up to 1½ times as broad as long.

Leaf lobes narrowly lanceolate; ventral lobes only 2 cells broad at base; leaves 2-2.2 times as long as broad; leaf cell walls ± clearly thickened at the corners, sometimes weakly nodose; dorsal cortical cells 65-85(95) μ long, clearly rectangular; leaves not fragile.....*A. cunninghamii*

Leaf lobes triangular-lanceolate; ventral lobes 3(4) cells broad at base; leaves 1½ times as long as broad; leaf cell walls uniformly and insignificantly thickened; dorsal cortical cells quadrate to somewhat rectangular, 55-65 μ long; a large part of leaves usually broken off.....*A. laetevirens*

Excluded Species

Acromastigum fernandeziense S. Arn. (Ark. Bot. 2, 4(1): 10. 1957) seems at first glance to be an *Acromastigum*, but Arnell (1957) remarked that it "differs from all known species of the

genus by the dentate ventral margin of the leaves and the strongly dentated amphigastria." It also deviates from *Acromastigum* in its manner of branching (lacking terminal-lateral as well as terminal-ventral branching), its 2-lobed amphigastria (rather than 3-lobed or unlobed), its stem cross-section, which shows numerous very small cortical cells (rather than the seven greatly enlarged cortical cells normally found in *Acromastigum*).

A very thorough examination of available material led to the discovery of a few androecia. These occur in terminal or intercalary positions and exhibit amphigastrial antheridia, which are known thus far only in *Herberta*, *Mastigophora*, and *Triandrophyllum*. It is evident that *Acromastigum fernandeziense* agrees in all essential features with *Triandrophyllum*, deviating from that genus only in the position of the antheridia. According to Fulford and Hatcher's description (1959), the antheridia occur in the axils of the amphigastria and also in the ventral and dorsal axils of lateral leaves. In *Acromastigum fernandeziense*, however, they are apparently restricted to the ventral axils of lateral leaves, in addition to the axils of amphigastria, and the lateral leaves are therefore inflated only ventrally. I saw only a few androecia, and the situation in especially robust plants might be quite different. In view of the close agreement in other respects, I do not consider this difference important enough to exclude *A. fernandeziense* from *Triandrophyllum*.

Triandrophyllum fernandeziense (S. Arn.) n. comb. *Acromastigum fernandeziense* S. Arn., Ark. Bot. 2, 4(1): 10. 1957.—Planta dioica (solum ♂ visa), mediocris, ad 4 cm. longa, corticola, dense depresso-caespitosa, siccando olivaceo-viridis-brunneola, saepe ventraliter purpurascens.

Caulis tenax ramis semper intercalaribus ventralibus (ex angulo amphigastriorum) et interdum—basi imprimis—flagellis intercalaribus ventralibus foliis simplificatis aequaliter in omnibus 3 seriebus merophytorum. Rhizoidea fasciculata, solum ad basin foliorum simplificatorum flagellorum, caulibus normaliter foliatis desunt. Cellulae corticales conspicuo incrassatae, longe rectangulatae, 15 × 50-80 μ metientes, cuticula dense striato-papillata. Sectione transversali caulis cellulae numerosae, omnes parietibus conspicuo incrassatis, sed cellulae corticales magis incrassatae, parum brunneae, 1-2-stratosae, parum minores quam cellulae medullares.

Folia caulina incuba, insertione ventraliter conspicuo arcuato, in medio stricto obliquo, dorsaliter leviter arcuato, subrecte patula, plano-disticha, leviter imbricata-contigua, longe ovata, apice breviter biloba, lobis acutis, sinu acuto basi obtuso, marginibus parum

irregularibus, basi ventrali dentato–spinosa–appendiculata, basi dorsali conspicuo arcuata, 1-2 papillis vel dente brevi armata.

Cellulae foliorum apicales et marginales 16 × 24 μ medianae 20-30 μ metientes, basales elongatae ad 40 μ longae, cuticula minute et dense papillata, ad basin striato-papillata.

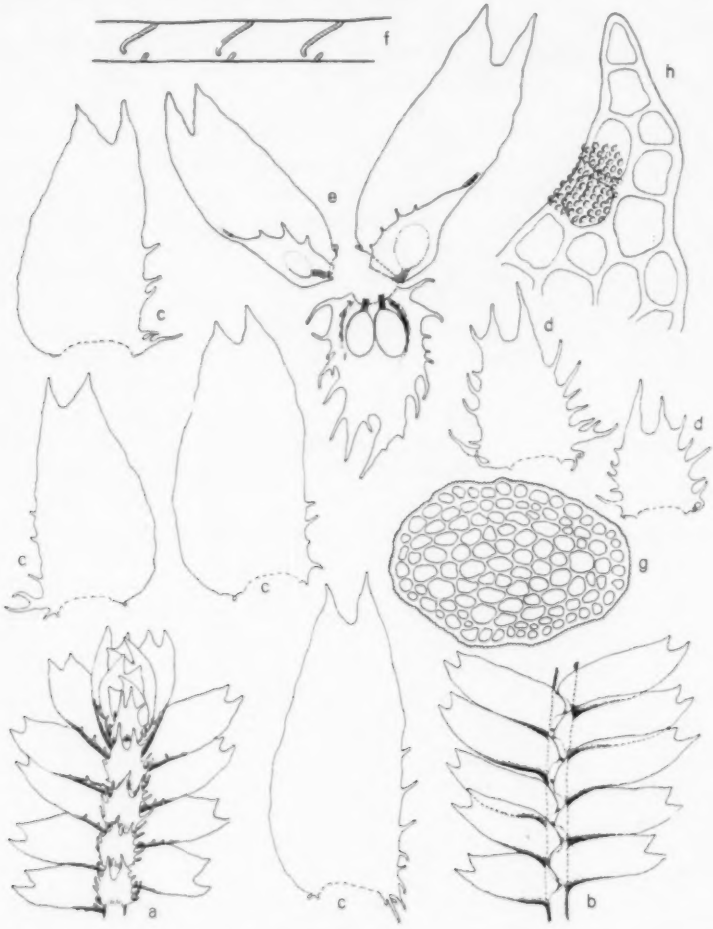

FIG. 4. *Triandrophyllum fernandeziense*. *a*. Portion of stem in ventral view, × 15. *b*. Portion of stem in dorsal view, × 15. *c*. Lateral leaves, spread out, × 29. *d*. Amphigastria, × 29. *e*. Whorl of androecial bracts, spread out, × 29. *f*. Schema of leaf insertion in lateral view, × 29. *g*. Stem cross-section, × 125. *h*. Cell pattern of a leaf tip, × 303. (All drawn from the type.)

Amphigastria saepe purpurata, transverse inserta, libera, ambitu ovata, basi angustata apice 1/4-1/3 biloba, lobis spinoso-laciniatis, marginibus spinoso-fimbriatis, spinis e cellulis elongatis formatis.

Androecia terminalia, posterius intercalaria, valde pauci-juga; antheridia plurimum bina in axilla amphigastriorum et singularia in angulo ventrali foliorum, pedicello bicellulari-seriato, pariete cellulis subquadraticis, minoribus. Folia et amphigastria androeciorum saccata, ceterum parum diversa a foliis caulinis.

Material examined. JUAN FERNÁNDEZ: On *Myrceugenia* bark, humid forest on steep slope above Plazoleta del Yunque, Masatierra, *C.* & *I. Skottsberg 209*, in 1955 (holotype, S).

REMARKS ON THE PATAGONIAN BAZZANIAE

According to Fulford (1959), four species of *Bazzania* occur in Patagonia: *B. peruviana* (Nees) Trev., *B. skottsbergii* (St.) Fulf., *B. chilensis* (St.) Fulf., and B. *convexa* (Thunb.) Trev.

Fulford (1946) cited *Jungermannia peruviana* Lehm. (Pug. Plant. 5: 18. 1833) as a synonym of *Bazzania peruviana*, and accordingly (1946, 1959) gave Lehmann as the parenthicial authority for the latter name. This is in error, however, for *Jungermannia peruviana* Lehm. is the basionym of *Cyclolejeunea peruviana* (Lehm.) Evans. The basionym for *Bazzania peruviana* is *Mastigobryum peruvianum* Nees (*in* G., L. & N., Syn. Hep. 220. 1845), and the designation of authorities should therefore read *B. peruviana* (Nees) Trev.

Herzog (1954) voiced strong doubt as to whether *B. peruviana* and *B. skottsbergii* are actually specifically different, and the characters of the ventral leaf-margins, recently reported by Fulford (1959)—strongly curved in *B. peruviana*, but straight in *B. skottsbergii*—do not seem to permit a clear distinction between the two species because the curved ventral leaf margin is usually demonstrable only *in situ;* as soon as the lateral leaves are spread out, the curvature of the ventral leaf-margin almost entirely disappears. No geographic evidence for the occurrence of two species is available, since plants of both expressions occur in Patagonia, as well as in Juan Fernández and Tristan da Cunha. I would therefore include *B. skottsbergii* in *B. peruviana* as a new synonym.

Herzog (1938) reported *Bazzania adnexa* (Lindenb. & Lehm.) Trev. from Patagonia (Chile). *B. adnexa* and *B. peruviana* are closely related. Nevertheless the former is distinguished by its toothed subapical leaf-margins and often strongly toothed amphigastria, whereas *B. peruviana* usually has nearly entire subapical leaf-margins and only weakly toothed amphigastria. (The amphi-

gastria of both species may be more or less lobed.) An investigation of the Patagonian specimen determined by Herzog as *B. adnexa* showed the subapical leaf-margins to be entire and the amphigastria only weakly toothed. I therefore consider it *B. peruviana*. There are, of course, Bazzanias of the Australian area very similar to *B. peruviana* and perhaps not specifically distinct from it; I have seen such plants from Australia and Tasmania. According to the descriptions, *B. novae-zelandiae* (Mitt.) Besch. & Mass. and also *B. sieberiana* (Lindenb.) Trev. are very similar to *B. peruviana; B. novae-zelandiae* was reported from Patagonia by Bescherelle and Massalongo (1889). The relationship of these names to each other still needs investigation. In any case, *B. peruviana* is the oldest name among them.

B. chilensis (St.) Fulf., which is closely allied to *B. breuteliana* (Lindenb. & Gottsche) Trev., is known from several collections from the Andes of Peru and Bolivia and also from a single specimen from Chile (*Lechler;* without locality data). In view of the unreliability of older locality designations, the occurrence of this species in Chile should be confirmed. Until then, I would regard the presence of *B. chilensis* in the Chilean flora with suspicion.

The genus *Bazzania* is obviously meagerly represented in Patagonia. Because of their own distributional areas and those of their nearest allies, *B. peruviana* and *B. convexa* (Thunb.) Trev., may be considered subantarctic elements. *B. chilensis*, on the other hand—if it actually occurs in Chile—may be regarded as neotropic in origin.

Acknowledgment

Dr. Howard Crum kindly undertook the translation of this paper from the original German. I wish to express best thanks for myself and also for the many readers who may read English more easily than German.

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INDUCED DIPLOIDY IN ATRICHUM FLAVISETUM

R. S. CHOPRA AND S. S. KUMAR[1]

Heitz (1926, 1942) suggested that bisexuality in mosses may have arisen as a result of chromosome doubling by apospory or by unreduced spores. Wettstein (1937) proved it by rearing diploid monoecious gametophytes from a haploid dioecious form of *Bryum caespiticium* Hedw. Lowry (1948) in *Mnium* and (1954) in *Atrichum* suggested the same relationship. Sharma (*unpubl.*) found in *Pogonatum microstomum* (R.Br.) Brid. that some plants with 14 chromosomes are male or female, while others are monoecious. The present investigation is an attempt to induce diploidy in male and female plants of a haplodioecious species of *Atrichum* and to compare the morphology and sex of such plants with those produced by the regeneration of setae. It has not been possible to maintain the cultures to study the sex because, owing to increasing heat, the plants die in May.

Materials were collected at Mussoorie in the western Himalayas (6000-7000 ft. alt.) in August and September of 1958 and 1959; mature capsules were also collected at Chakrota (6500-7500 ft. alt.). Knop's solution, full and half strength, with and without

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growth hormone, and the solution recommended by Johansen (1940) were used for the regeneration of setae. Whole setae as well as apical, middle, and basal parts, injured and uninjured capsules, and calyptrae were placed in nutrient solution. Male and female plants were placed separately in Knop's solution in petri dishes exposed to diffuse light. When the protonemata developed, they were transferred to colchicine solutions of 0.05%, 0.1%, 0.15%, 0.2%, 0.25% to 0.3% strength in distilled water for 48, 40, 36, 30, 24, and 18 hours, respectively. The treated protonemata were washed thoroughly until free of colchicine and then transferred to sterilized soil from Mussoorie. Protonemata developed from spores placed in the various strengths of colchicine were similarly transferred to sterilized soil. For comparative study, protonemata were mounted in 10% glycerine and sealed under the coverslip with a ringing medium. Temporary slides of different plant organs were prepared for morphological comparisons and microphotographs. Gametophytic chromosome numbers were determined by squashing young leaf tips in aceto-orcein.

Observations

Production of diploid gametophytes by the regeneration of setae on haploid plants. Setae growing from haploid plants with $n = 7$ (*fig.* 1) failed to regenerate in Knop's solution, but positive results were obtained in Johansen's solution with 10 p.p.m. of indole-3-acetic acid. Mature setae which had developed a red color or those where capsule differentiation was completed failed to regenerate. Only young green setae in which capsule differentiation had not started or had just started regenerated, giving the results shown in Table 1.

Plants of diploid constitution of $n = 14$ (*fig.* 2) developed from these protonemata were robust and dark-green, with numerous, brown, long and much branched rhizoids; stems 116 μ in diameter, the internodes 324 μ long; leaves small, tending to be perpendicu-

Table 1. Regeneration of setae in Johansen's solution with 10 p.p.m. of indole-3-acetic acid. (The experiments were begun on Aug. 28, 1959.)

Part of seta	*Total number*	*Number regenerated*	*Percentage of regeneration*	*Place of regeneration*	*Time*
Whole	100	26	26	Upper end	80 days
Upper	100	34	34	Upper end	80 days
Middle	100	—	—	—	—
Basal	100	—	—	—	—

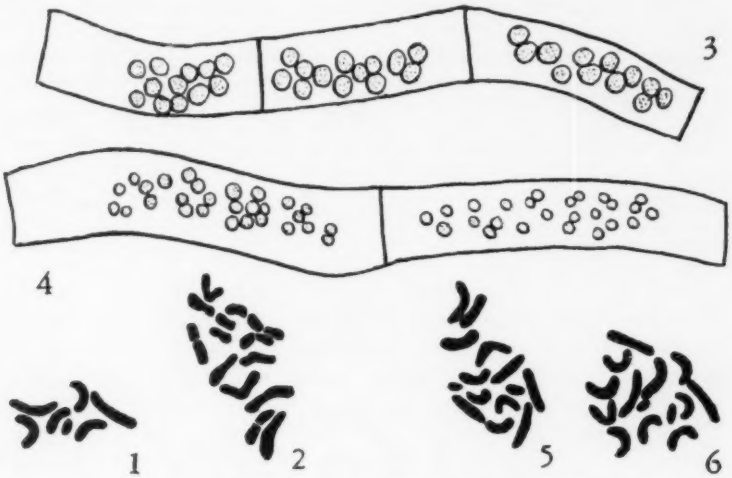

FIG. 1-6. *Atrichum flavisetum*. 1. Chromosomes, $n = 7$, × 2160. 2. Chromosomes of a diploid gametophyte produced by seta regeneration, n = 14, × 2160. 3. Cells of a protonema grown from an untreated spore, × 720. 4. Cells of a protonema grown from a spore treated with 0.2% colchicine, × 720. 5. Chromosomes of a diploid plant grown from a colchicine-treated spore, $n = 14$, × 2160. 6. Chromosomes of a diploid plant produced by treating the protonema of a haploid plant with 0.2% colchicine, $n = 14$, × 2160.

lar to the axis of stem; basal cells of the leaf nearly rectangular, 50 × 15 μ, upper cells elongate-rhomboidal, 50 × 16 μ, with 22-28 chloroplasts.

PRODUCTION OF DIPLOID GAMETOPHYTES FROM GERMINATED SPORES. Spores placed in normal Knop's solution showed rapid germination, while those placed in the above-mentioned concentrations of colchicine showed no germination 0.3% solution. In 0.2% colchicine balloon-like swellings were produced by the germ tube. Comparative studies of protonemata from spores germinated in different colchicine concentrations are given in TABLE 2.

The plants produced from untreated spores and those treated by 0.05%, 0.1% and 0.15% colchicine solutions did not show any macroscopic or microscopic differences, whereas those produced in 0.2% solutions were diploid, with $n = 14$ (*fig.* 5), and they were hardy, robust, and comparatively longer with an extensive rhizoidal system; stems narrower in diameter; leaves dark green; upper cells of the leaf elongate-rhomboidal, basal cells rectangular, with 24-30 chloroplasts in each cell.

TABLE 2. Comparison of protonemata developed in various concentrations of colchicine.

Characters of protonemata	*Protonemata from untreated spores*	*Protonemata in 0.05% colchicine*	*Protonemata in 0.1% colchicine*	*Protonemata in 0.15% colchicine*	*Protonemata in 0.2% colchicine*
Length of cell	70-72 μ } *Fig. 3*	70-72 μ	70-72 μ	70-72 μ	117 μ } *Fig. 4*
Breadth of cell	12 μ	12 μ	12 μ	12 μ	12 μ
No. of chloroplasts per cell	10-15	10-15	10-15	10-15	28-32
Size of chloroplasts	4 μ	4 μ	4 μ	4 μ	2-3 μ
Time taken for bud formation after transfer to soil	10 days	12 days	12 days	14 days	34 days

DIPLOID GAMETOPHYTES FROM COLCHICINE-TREATED PROTONEMA DEVELOPED FROM MALE AND FEMALE PLANTS. Protonemata developed from male and female plants in Knop's solution were treated with various concentrations of colchicine as indicated above. The most suitable concentration proved to be a 0.2% colchicine solution for 30 hours. Success of the concentration was confirmed by the diploid chromosome number $n = 14$ determined from leaf tips (*fig.* 6). Bud formation on properly affected protonemata was delayed by 36 days. Morphological comparisons of haploids and diploids are given in TABLE 3.

DISCUSSION

It has been noted that relatively younger setae respond favorably, while the older ones fail to regenerate. These findings are in line with those reported by LaRue (1930) in *Amblystegium serpens* (Hedw.) BSG, *Ditrichum pallidum* (Hedw.) Hampe, *Mnium cuspidatum* Hedw., and many others. Meyer (1942) found a similar situation in *Physcomitrium turbinatum* (Mx.) Brid. The lack of response in older setae may result from the loss of food materials consumed by the developing capsule. On the other hand, in comparatively younger setae the necessary amount of food is available because the capsular part is still in the process of differentiation. This factor alone cannot be insisted on, however, until more genera are studied. Observations by LaRue (1930) are noteworthy in this connection. He considered that contact of a particular organ of the gametophyte with the substratum may be important in influencing its regenerative capacity; this perhaps explains the rarity of seta regeneration in nature, as the setae never come in contact with the soil.

Some of the observations concerning colchicine polyploidy in mosses need comment. It has been seen that normal spore germination occurs in aqueous solutions of 0.05%, 0.1%, 0.15% colchi-

TABLE 3. Comparison of haploid and diploid gametophytes grown from colchicine-treated protonemata produced by plants of both sexes.

Morphological characters	*Untreated ♂ plants*	*Untreated ♀ plants*	*Colchicine-treated ♀ plants*	*Colchicine-treated ♂ plants*	*Plants regenerated from setae*
Rhizoids	Relatively few, less branched	Relatively few, less branched	Relatively more numerous, very much branched	Relatively more numerous, very much branched	Relatively more numerous, very much branched
Color of stem	Green	Green	Dark-green	Dark-green	Dark-green
Diameter of stem	158 μ	191 μ	99 μ	87 μ	115 μ
Length of internode	294 μ	377 μ	324 μ	295 μ	324 μ
Angle of leaf to stem	Narrow	Narrow	Broad	Broad	Broad
Color of leaf	Green	Green	Dark-green	Dark-green	Dark-green
Basal cells of leaf					
Shape	Rectangular	Rectangular	Rectangular	Rectangular	Nearly rectangular
Length	41 μ	45 μ	56 μ	55 μ	50 μ
Breadth	16 μ *Fig. 7*	14 μ *Fig. 15*	15 μ *Fig. 14*	15 μ *Fig. 12*	15 μ *Fig. 8*
Number of chloroplasts	8-14	8-14	24-28	24-32	22-30
Size of chloroplasts	4 μ	4 μ	3 μ	3 μ	3 μ
Upper cells of leaf					
Shape	Parenchymatous	Parenchymatous	Elongate-rhomboidal	Elongate-rhomboidal	Elongate-rhomboidal
Length	18 μ	19 μ	48 μ	48 μ	49-50 μ
Breadth	14 μ *Fig. 10*	14 μ *Fig. 13*	16 μ *Fig. 16*	17 μ *Fig. 9*	15 μ *Fig. 11*
Number of chloroplasts	6-12	4-12	18-26	20-28	22-30
Size of chloroplasts	4-5 μ	4-5 μ	3 μ	3 μ	2-3 μ

cine strength, but in 0.2% solution the first germ cell shows an enormous size similar to that seen by Levan (1938) and Östergren (1944) in some species of *Allium* and by Mehra and Loyal (1954) in two species of ferns. Adverse affects of this drug are also discernible in the delay of spore germination, as well as the late development of buds and poor growth at initial stages. These observations agree with those of Wettstein (1924). Such growth stunted by colchicine was ascribed to a slower rate of cell division by Wettstein (1924) and Kostoff (1940). Two other contributory factors are the smaller amount of growth hormones in polyploids than in their corresponding diploids, as suggested by Gustafson (1944), and the effects of environment on newly formed polyploids (Müntzing, 1936).

Gigantism associated with polyploidy was noticed by the present writers, confirming earlier observations by Tobler (1931) in species of *Funaria* and Chopra and Bhandari (1959) in *Atrichum obtusulum* (C. M.) Jaeg. and *Atrichum flavisetum* Mitt., but the complete absence of quantitative differences between haploids and artificially produced diploid gametophytes recorded by Lowry (1954) indicates that polyploidy does not always induce gigantism. This has been explained by Tobler (1931) by assuming that the nature of the plant's response to polyploidy may be governed by its genotypic constitution.

In haploid plants, the leaves possess, as usual, two types of cells, the basal ones rectangular, the apical ones rhomboidal. In diploid plants, however, cells in the apical part are elongate-rhomboidal, while the basal cells undergo but little change. This change in shape and size of the apical cells may result from an increased physiological demand to accommodate a much larger number of chloroplasts than in the corresponding cells in haploids.

Acknowledgments

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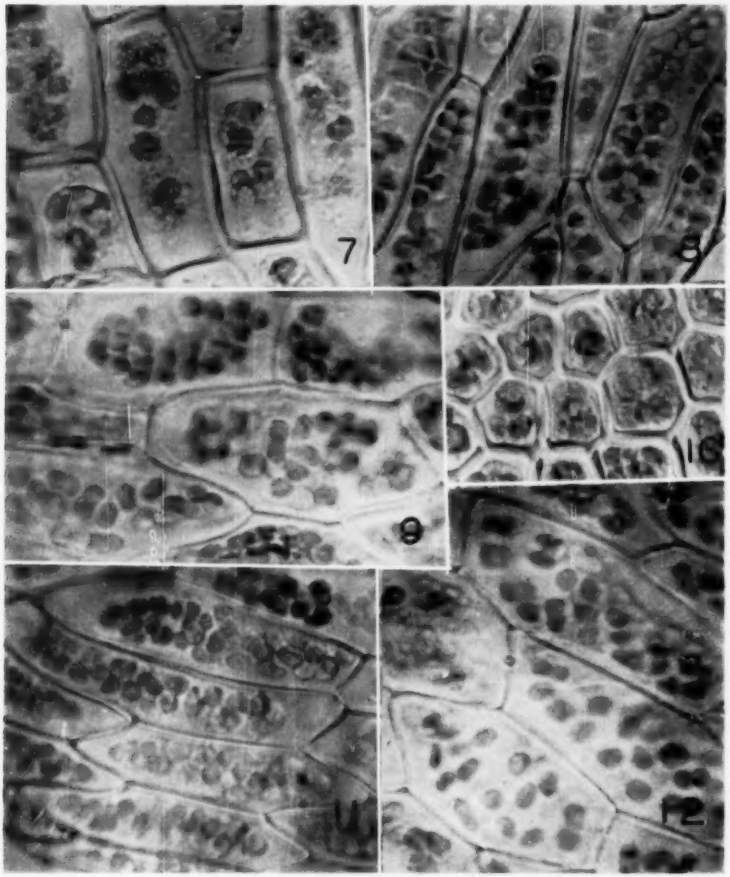

FIG. 7-12. *Atrichum flavisetum*, leaf cells. 7. Basal cells from an untreated male plant. 8. Basal cells from a diploid produced by seta regeneration. 9. Upper cells from a male plant treated with colchicine. 10. Upper cells from an untreated male plant. 11. Upper cells of a plant produced by seta regeneration. 12. Basal cells from a colchicine-treated male plant. (All figures × 587.)

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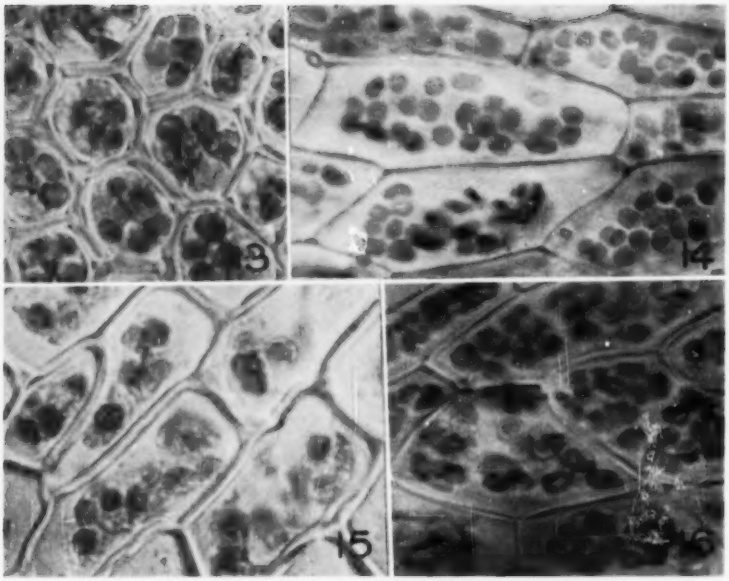

FIG. 13-16. *Atrichum flavisetum, leaf cells.* 13. Upper cells from an untreated female plant. 14. Basal cells from a colchicine-treated female plant. 15. Basal cells from an untreated female plant. 16. Upper cells from a colchicine-treated female plant. (All figures × 587.)

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A COMPARATIVE STUDY OF GENERATION FROM ISOLATED GAMETOPHYTIC TISSUES IN MNIUM

NELS R. LERSTEN[1]

Moss gametophytes exhibit a remarkable totipotency which is realized by formation of rhizoids, protonemata, intermediate structures, or direct buds from isolated tissues. Whole gametophytes may then differentiate from these new structures. This has been observed repeatedly and incorrectly termed "regeneration." True regeneration is the return to an original condition, *e.g.*, a new distal half formed from the basal half of a severed leaf; this does not occur in mosses. Instead there is "generation," or proliferation of new structures not present before.

"Leaves" of mosses are morphologically much simpler than true leaves or even the microphylls of lower tracheophytes. This apparent simplicity is belied by their diverse proliferation behavior (*table* 1).

TABLE 1. Proliferation variation in mosses.

	Proliferation pattern	Citation
Physcomitrium turbinatum	General	Meyer, 1942; Kachroo, 1954.
Atrichum undulatum	Mostly upper third	Gemmell, 1953.
Pogonatum microstomum	Lamellae, mostly middle zone.	Chopra & Sharma, 1958.
Funaria hygrometrica	Decrease from apex to base.	Bopp, 1954.
Brothera leana	Most distally, less basally, least in middle.	Noguchi & Furuta, 1958.
Merceya ligulata	Basal cells only.	——, 1956.
Merceya gedeana	General, but mainly proximal.	——, 1956.

Besides these varied patterns, other species, *e.g.*, *Ceratodon purpureus*, *Bryum cellulare*, and *Neckera pennata*, fail completely to generate under all attempted experimental conditions (LaRue, 1930; Narayanaswami & Lal, 1957). Added complexities are differences in type of structure produced and variation in time of proliferation.

Much previous work has been strictly descriptive, with no attempt at explanation. Some recent studies have probed more deeply, not only describing in detail proliferation behavior under various conditions (MacQuarrie & von Maltzahn, 1959; von Malt-

[1] Dept. of Botany, University of California, Berkeley; contribution from the University of Michigan Biological Station.

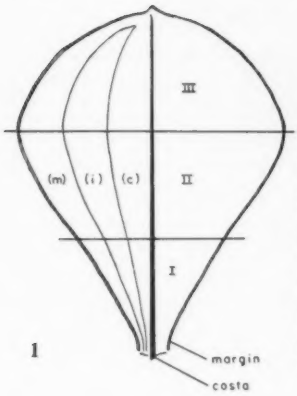
zahn, 1959; von Maltzahn & MacNutt, 1958), but venturing hypotheses to explain it. The present experiments were primarily intended as such a study. A secondary objective was to test the use of proliferation pattern as a taxonomic tool.

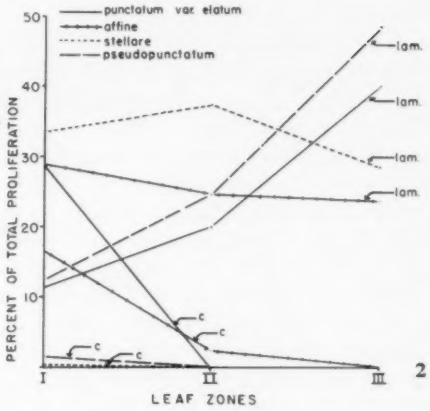
Materials and Methods

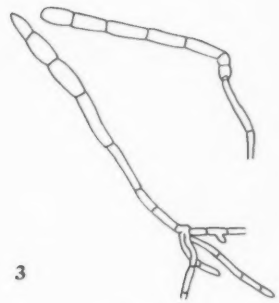
The genus *Mnium* was chosen because its large, usually distant leaves provide convenient experimental material. Some species have a differentiated margin; thus possible influences of different tissues could be investigated. Six species and one variety were investigated: *M. affine*, *M. cuspidatum*, *M. punctatum*, *M. punctatum* var. *elatum*, *M. pseudopunctatum*, *M. spinulosum*, and *M. stellare*. Adequate quantities were obtained from the vicinity of the University of Michigan Biological Station, Pellston, Mich. All work was done there during the summer of 1960.

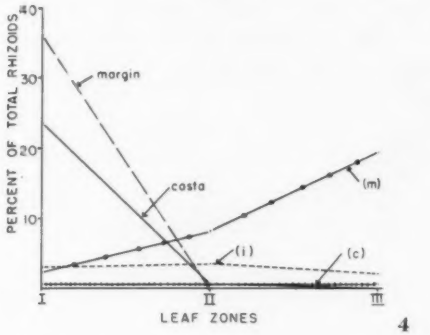
Knop's medium (Bold, 1936), in liquid form, was exclusively employed except for one experiment using stainless-steel distilled water. The culture containers were small, clear, polystyrene boxes ($3/4 \times 3/4 \times 7/8''$ in dimensions), which are biologically inert (Lersten & Voth, 1960). Illumination was from an overhead bank of two 40-watt white fluorescent tubes of approximately 100 ft.-c. intensity. In addition, diffuse daylight came from a north-facing window nearby. Temperatures were not controlled. The experiments were largely comparisons between groups under identical conditions, and their validity was therefore assumed. No special efforts were made to eliminate contaminating organisms, except that plants were vigorously washed in distilled water before all experiments. Only three cultures developed noticeable contaminations of green algae, and only occasional small tufts of mycelia were seen. The mosses appeared to be unaffected by these contaminants, at least during the experimental period.

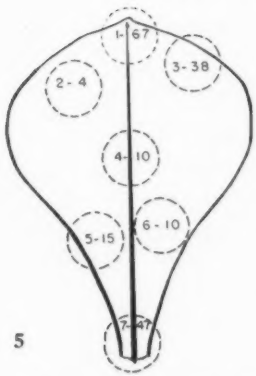
The results of most experiments were described as number and distribution of proliferation. For more precise description, leaves were divided into three (proximal, middle, distal) transverse zones. Within each zone were recognized costa, margin, and lamina. The laminal area was in turn subdivided longitudinally into three areas: marginal (*m*), intercalary (*i*), and costal (*c*) (*fig.* 1). Graphs were constructed by using as points the percentage of total leaf proliferation in any selected area. On some graphs only certain leaf areas were considered; for such graphs the sum of the percentages do not equal 100%, since all proliferation is not included. All experimental material was distributed by means of a table of random numbers.











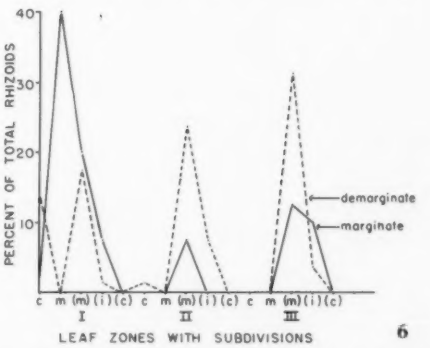


FIG. 1-6. Generation from the leaves of *Mnium*. 1. Division of leaf into generation zones (I, proximal; II, middle; III, distal; *m*, marginal; *i*, intercalary; *c*, costal). 2. Distribution of costal and laminal proliferation in four species of *Mnium*. 3. Proliferation from isolated paraphyses of *Mnium affine*

Comparison of Generation Patterns

Sixty leaves, 20 each from apex, middle, and base, were excised from 20 gametophytes of each species. Each group of 20 was divided into two groups of ten, one cultured in Knop's, the other in distilled water. After ten days, and again after four weeks, they were examined. A comparison of distribution patterns was disappointing, because tiny bits of stem inadvertently left attached to many of the leaves suppressed proliferation. A striking exception was noted in *Mnium affine* and *M. stellare,* where isolated leaves and those with attached stem pieces proliferated equally well.

The groups in distilled water behaved similarly, except that here proliferations were short, thick rhizoids; no protonemata developed except in *M. stellare,* which produced them equally well in either medium. Apparently also caused by differences in the two media was the increased generation of shoots directly from axils or leaf surfaces in distilled water (*table* 2).

The proliferation which occurred was in selective areas. The laminal cells adjacent to the margin were especially active in most species.

A repeat experiment was set up with ten leaves of each species, from which all stem tissue was carefully removed. After ten days

Table 2. Shoot generation in different media

	Distilled Water			Knop's Medium		
	Axil	Leaf		Axil	Leaf	
		Directly	From protonemata		Directly	From protonemata
M. affine	12	7	0	6	0	0
M. stellare	14	4	1	5	0	0
M. cuspidatum	5	0	0	4	0	0
M. spinulosum	4	2	1	0	0	0
M. punctatum	10	0	0	0	0	0
M. punctatum var. *elatum*	14	0	0	0	0	0
M. pseudopunctatum	0	0	0	0	0	0
Totals	59	13	2	15	0	0
Total in distilled water = 74				Total in Knop's = 15		

(upper) and *M. cuspidatum* (lower), × 31. 4. Proliferation pattern in isolated leaves of *Mnium punctatum* var. *elatum.* 5. Number of proliferations from seven discs taken from the indicated positions of the leaf of *Mnium punctatum* var. *elatum.* 6. Proliferation distribution from intact and demarginated, isolated leaves of *Mnium punctatum* var. *elatum.*

in culture, proliferation distribution was noted. *Mnium punctatum* and *M. spinulosum* had not proliferated, but in the four species generating the significant changes were in the lamina and costa (*fig.* 2). As shown on the graph (*fig.* 2), *M. stellare* and *M. spinulosum* have a more generalized proliferation pattern than *M. punctatum* and *M. punctatum* var. *elatum*, *i.e.*, without marked changes from one zone to another. The latter two species showed an increase of laminal proliferation distally.

To determine possible adaxial-abaxial differences in number and length of proliferations, the data were rearranged (*table* 3). There was significantly more proliferation abaxially than adaxially. Proliferation length was not affected by this apparent polarity, since relative length and number of proliferations match closely for each side. *Mnium pseudopunctatum* showed less polarity than the other species.

TABLE 3. Correlation of number and length of proliferations on opposite leaf surfaces.

	NUMBER				LENGTH			
	Adaxial		Abaxial		Adaxial		Abaxial	
	No.	% of total	No.	% of total	Mm.	% of total	Mm.	% of total
M. punctatum var. *elatum*	1	3.0	34	97.0	1	5.0	17	95.0
M. affine	60	19.0	257	81.0	29	13.7	183	86.3
M. stellare	76	30.0	182	70.0	81	30.0	174	70.0
M. pseudopunctatum	239	46.6	274	53.4	220	49.0	229	51.0

An experiment was performed using only *Mnium punctatum*, *M. punctatum* var. *elatum*, and *M. pseudopunctatum* to investigate the taxonomic status of this controversial species complex (Lowry, 1948). Twenty leaves, ten from near the apex of vegetative stems and ten from the perichaetium, were excised from each species. After ten days the proliferation pattern was found to be similar for all three species; the only suggestive difference was a lack of adaxial-abaxial polarity in *M. pseudopunctatum*, which had been previously noted (*table* 3). In the perichaetial leaves of this species, adaxial proliferation actually exceeded the abaxial.

Twenty isolated paraphyses from each of the species except *M. stellare* were also cultured. Proliferation occurred only from three paraphyses of *M. affine* and ten of *M. cuspidatum*. Protonemata invariably arose basally from the basal cell of the paraphysis

(*fig.* 3). This is one of the few reports of proliferation from isolated paraphyses (Reese, 1955).

Experiments using Mnium punctatum var. elatum

Several experiments using only *M. punctatum* var. *elatum* were undertaken to investigate the relation between proliferation and various tissues. To corroborate observations of stem suppression of leaf proliferation 20 leaves were excised, ten with 1 mm. pieces of stem attached, and ten without. All leaves came from just below the perigonium, where size is maximum.

After 11 days there was no proliferation from the leaves attached to stems but extensive proliferation from the stem pieces. A total of 345 rhizoids were produced, 307 abaxially and only 38 adaxially. The combined pattern of both sides is shown in figure 4. Differences of distribution from basal to apical areas of the leaf are evident.

Microscopic observation revealed that what had been considered marginal proliferation in zone I of this species was actually from an "extramarginal" row of thin-walled, lamina-like cells which arose outside the differentiated border in the lower third of the leaf and continued past the point of insertion and down the stem as a ridge terminating at a lower leaf insertion. These ridges gave rise to almost all stem proliferation.

Costa, lamina, and margin had been shown to generate differently in the isolated leaf. To test them separately, ten of each of these parts were isolated and cultured for 14 days. The margin itself did not generate, but the above-described extramarginal cells did. The costa proliferated only from the brownish proximal area and not at all from the more distal green portions. Isolated laminal tissue exhibited some proliferation. The influence of these three tissues in combination was now investigated. Seven discs from different parts of the leaf were punched out from ten leaves using capillary tubing 1 mm. in diameter; these were cultured for ten days. The position from which each disc was removed, its number, and total proliferation are shown in figure 5.

This experiment showed nicely decreasing proliferation from the tissue combinations, costa + lamina + margin to lamina + margin to lamina + costa to lamina. Almost as clear-cut was the decrease in proliferation from apex to base as represented by discs 1 and 7, 3 and 5. Discs 2 and 6 did not follow this pattern, but this may be because they were not in contact with costa or margin, which did show an apparent gradient from apex to base.

Another experiment was conducted along these same lines:

1 mm.^{2} pieces of isolated laminal tissue were placed in contact with isolated pieces of costa or margin. There were ten replicates of each condition and ten isolated laminal pieces as a control. After ten days a similar proliferation was noted in all pieces of laminal tissue. Apparently more than mere contact is required for any influence by one tissue on another.

The effect of complete margin removal was tested. Eight leaves were divided into two groups of four. From one group the margin was carefully and completely stripped off; the other group was left intact as a control. After 12 days the results were as shown in figure 6. A similar pattern was seen to exist for both groups except for marginal proliferation, which had to be nil in the demarginated group. In demarginated leaves there was much generation from the outermost cells of the lamina, which normally would be immediately adjacent to the margin. The doubling of generation from 40 in the control group to 80 in the demarginated group does not fit the hypothesis of margin stimulation which had seemed reasonable on the basis of the experiments previously described.

The dissimilar proliferation behavior of costa, lamina, and margin, coupled with complete suppression in attached leaves (except in *M. stellare* and *M. affine*), suggested the possibility that an inhibitor passes differentially through the leaf tissues. To test this hypothesis 20 similar leaves, each with 1 mm. of attached stem, were divided into 4 groups of 5 leaves each and treated as follows: (1) control group; (2) margin severed at base; (3) lamina severed at base; and (4) costa severed at base. After 13 days the results were tabulated (*table* 4). They agree with the hypothesis and suggest passage of an inhibitor primarily through the costa and secondarily through the margin

The abaxial-adaxial polarity was studied in more detail with var. *elatum*. Possible stimulation by substrate contact was tested by placing five leaves with adaxial surface in contact and five

TABLE 4. Proliferation distribution in variously severed leaves of *M. punctatum* var. *elatum*.

	Rhizoid Distribution			
	Zone I	Zone II	Zone III	Totals
Control	0	0	0	0
Cut margin	12 (costa)	2 (margin)	7 (margin)	21
Cut lamina	0	0	0	0
Cut costa	36 (costa)	7 (costa) 11 (margin)	17 (margin)	71

leaves with abaxial surface in contact. After 12 days the group with abaxial surface contact had 116 rhizoids abaxially and only 16 adaxially. The group with the adaxial surface in contact had 96 rhizoids abaxially and 76 adaxially. A repeat experiment gave essentially the same results, suggesting an innate polarity. Heald (1898) reported no innate dorsiventral polarity in *Mnium rostratum* leaves from the same experiment.

A few simple experiments were conducted using stem tissue of the var. *clatum* to see what characteristics its proliferation had. It had been previously observed, for all species, that the stem proliferated faster than the leaf and with greater vigor. In *M. punctatum*, *M. pseudopunctatum*, and *M. punctatum* var. *clatum* proliferation was only from the ridges which are extensions of the extramarginal row. The basal portion, however, where these ridges became obscure, exhibited proliferation generally over the whole stem surface.

Ten gametophytes of equal height were denuded of leaves and each cut into three equal sections. The three groups were cultured separately for 16 days. Proliferation apparently increased from apical to middle to basal sections, but it was too great to get quantitative data. Shoots arose in the distal two sections, but none from the proximal section. These shoots were axillary in origin. To test the possible influence of the axillary areas on rhizoid production 20 1 mm. stem sections were cut, ten with an axil and ten without. No differences were noted between the two groups.

Generation was never observed at ends of cut stem sections, indicating that the internal tissues were incapable of it. Investigating this further, several stem sections were cut longitudinally, exposing large areas of internal tissue. After 22 days there had been no generation except from the external ridges. Because of technical difficulties internal stem tissue was not cultured completely separate from the external layer, so that a possible inhibitory factor could not be ruled out.

Discussion

The work reported here, while only preliminary to a more sophisticated approach, has showed that the various tissues of leaf and stem differ in generative capacity and that there are further differences within each type of tissue. At a more general level, differences can be discerned between species within a genus. Except for the work of Noguchi and Furuta (1956) on two species of *Mercelya*, this is the only attempt known to the author of a comparative generation study of several species of one genus.

As a taxonomic character proliferation behavior of leaves and paraphyses may have value, especially in the case of controversial species, varieties, etc. The results of the attempt to apply the technique in *Mnium* was perhaps not impressive, but the repeated and anomalous lack of an adaxial-abaxial polarity in *M. pseudopunctatum* indicates a possibly constant character.

The experiments comparing species showed some definite differences, such as the rather sharp distinction between *Mnium affine, M. stellare,* and the other species. The poor generation of *M. punctatum* and *M. spinulosum* cannot be uncritically accepted as characteristic because of lack of knowledge of the past history of the plants used. This uncertainty makes it mandatory for any really valid work to be done with only clonal material of known origin, grown under known conditions, preferably on nutrient media. This has been done by von Maltzahn and MacNutt (1958). Lodge (1959) has applied culture techniques to taxonomic problems in *Drepanocladus* with success.

The formulation of an hypothesis to explain the stimulus and pattern of proliferation is difficult on the basis of these experiments. Even the presumably universal non-proliferation of attached leaves had exceptions in *Mnium affine* and *M. stellare.*

The hypothesis of inhibition of leaf proliferation by high auxin concentrations moving into the leaf from the apical meristem (MacQuarrie & von Maltzahn, 1959) was nicely corroborated by the experiment in which attached leaves had either costa, lamina, or margin severed. Enhancement of proliferation by complete removal of the margin strengthened this hypothesis. A related phenomenon is the *in situ* germination of gemmae of *Lunularia* when the thallus apex is excised. Auxin proved to be the inhibitor here (LaRue & Narayanaswami, 1957).

Unfortunately, the experiments which showed the stimulatory influence of costa and margin when in contact with the laminal tissue are in opposition. Furthermore, the great proliferation from stem and base of costa is difficult to explain if these tissues are the very ones with the highest concentration of the postulated inhibitory substance. This difficulty might be avoided by assuming translocation of the inhibitor only through the central core of hydroids of the stem. The costa is known to have hydroid-like cells which penetrate almost to the central core of the stem (Parihar, 1959), and translocation, at least of water, has been reported (Bowen, 1933). Such an hypothesis could explain the inability of internal stem tissue to proliferate, and also the proliferation from the basal part of the costa only, where it is thickest and most stem-like.

SUMMARY

1. Isolated leaves of six species and one variety of *Mnium* were cultured in Knop's medium and analyzed for their pattern of proliferation.

2. No leaves with attached stem tissue proliferated except in *M. affine* and *M. stellare*.

3. Isolated leaves of *M. spinulosum* and *M. cuspidatum* showed no reaction; *M. affine* and *M. stellare* had generalized distribution while the other three species showed costal and extramarginal basal proliferation and marginal proliferation distally.

4. Under the experimental conditions it was impossible to separate definitely all species on the basis of their proliferation distribution.

5. All species except *M. pseudopunctatum* had a marked increase of proliferation from the abaxial surface.

6. This abaxial selectivity continued no matter which surface was in contact with the substrate, but contact surfaces always had more proliferation than the same surface not in contact.

7. Paraphyses of six species tested proliferated only in *M. affine* and *M. stellare*, and in these from the basal cell.

8. Leaves of *M. punctatum* var. *elatum*, with attached stem sections, were severed at costa only, margin only, lamina only, and not at all (control). Greatest proliferation followed costal severance, and much less followed marginal severance; none occurred in the other two cases.

9. Stem proliferation was usually only from the leaf margins which continued as ridges down the stem. Internal stem tissue did not produce proliferations.

10. Internal mechanisms of proliferation, in terms of regulatory substances, are discussed.

ACKNOWLEDGMENT

The author wishes to credit the initial suggestion of a comparative study to Dr. A. J. SHARP and to acknowledge his generous advice and stimulation during the course of this investigation, as well as during the preparation of the manuscript.

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POTTIA DAVALLIANA IN ONTARIO AND ELSEWHERE IN NORTH AMERICA

HARRY WILLIAMS[1]

Since September 1958, when the author first found it at Millbrook, *Pottia davalliana* (Sm.) C. Jens. [*P. minutula* (Schleich.) Fürn.] has been collected in 13 counties of southern Ontario, from Hastings in the east to Lambton in the west, and north as far as the Bruce Peninsula. It has proved to be fairly general and abundant where found and is evidently an established member of the bryophyte flora of the province. It probably grows in all counties where there are calcareous soils and is no doubt more frequent elsewhere in North America than the few previously recorded collections would indicate. Though the plants are small they are quite distinctive and are more likely to have been overlooked in the past than mistaken for some other species, *P. truncata*, for instance.

[1] Millbrook, Ontario.

The earliest American report of *P. davalliana* may be the distribution (as *P. minutula*) of material from Texas by Sullivant and Lesquereux (1865). This was collected near San Marcos by Charles Wright, between 1849 and 1851, according to Whitehouse (1954). I have seen two duplicates of this collection (no. 117) in the herbarium of the National Museum of Canada: the plants are good *davalliana* except for the spores, which are sparingly low-papillose to nearly smooth, instead of echinate as is normal for the species. This difference led Wareham (1939) to separate these plants as *P. texana*, but it is of only trivial importance here, and the plants should remain under *P. davalliana*. Similarly aberrant plants also occur in at least part of the Ontario population. Thus, a collection from Ipperwash, Lambton Co. (*Davison* 116), shows some plants with spores almost smooth but others with them normally echinate. Some 20 other collections from other counties have shown only normal spores, and bearing in mind the variability of the species it is clear that no significance can be attached to such occasional abnormalities. Typical *P. davalliana* has been reported in one collection from Stanford, California, by Steere *et al.* (1954). (They give there the first chromosome count for the species: $n = 30$.) Four other collections at the National Museum of Canada have plants that are either immature or have smoothish spores. They are *Orcutt* 5565, 5567, from Laredo, Texas, and *Steere* 17532, 17536, from Los Cedros Island, Baja California.

In Ontario, *P. davalliana* has been collected on bare calcareous soil in arable and pasture fields, on roadside banks and ditch sides, and in lawns. Some of the species regularly associated with it here are *Phascum floerkeanum*, *P. cuspidatum*, *Ephemerum cohaerens*, *E. crassinervium*, *E. spinulosum*, and *Dicranella varia*. It shows itself more calcicolous than *P. truncata* and can flourish on fairly recent exposures of calcareous subsoil where the latter does not grow. *P. davalliana* is also a plant of stouter texture than *P. truncata* and is usually seen in more exposed sites than the latter. Both species commonly behave as fall and winter ephemerals, but *P. davalliana* can persist through the summer in moister habitats, and the plants here show growth continued by apical innovations. I have noticed some plants subjected to shallow burying by soil wash with three years' growth formed in this way.

When growing in the open in Ontario, mature plants of *P. davalliana* are about three mm. high to the top of the capsule, with the leaves spreading in a stellate rosette from the very short stem. Robust plants locally are up to five mm. high, having longer stems than the exposed plants. The latter are reddish-brown when mature (about the same color as *Phascum floerkeanum*) and when

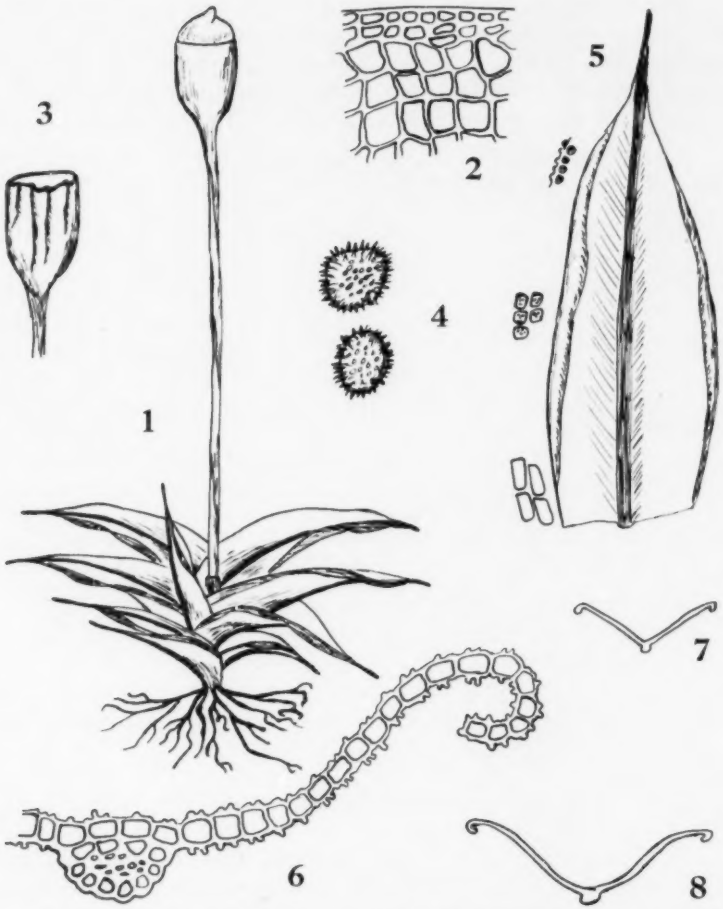

FIG. 1-8. *Pottia davalliana*. 1. Plant with mature sporophyte, × 23. 2. Cells of capsule mouth, × 305. 3. Empty capsule, × 30. 4. Spores, × 365. 5. Dorsal view of leaf, × 72; cells, × 270. 6. Cross-section of leaf, × 310. 7. Shape of cross-section of leaf, one-third of length from tip, × 78. 8. Shape of cross-section of leaf, two-thirds of length from tip, × 78.

they grow in dense patches, as they usually do, are easily spotted in the field. Other diagnostic features are the recurved leaf margins; the densely papillose upper leaf cells, about 12-14 μ wide; the narrow capsule, about 0.7 mm. long, often narrowed slightly to the mouth which is about 0.35 mm. wide; and the echinate spores, about 30 μ in diameter (25-35 μ).

I should like to thank my wife (the former Claire Davison) for her assistance in making many of the collections and for preparing the drawings. Listed below are collections represented in the National Museum of Canada. Duplicates of some of the author's collections have been deposited in the principal American herbaria.

CANADA. ONTARIO: Stokes Bay, Bruce Peninsula, *Williams*, Oct. 12, 1959; Millbrook, Durham Co., *Williams* 1363, 1429, 1459, 1477; Dundalk, Grey Co., *Williams* 1624; Marmora, Hastings Co., *C. Williams* 215; Ipperwash, Lambton Co., *C. Davison* 116; London, Middlesex Co., *C. Williams* 233; South Monaghan, Northumberland Co., *C. Williams* 218; Columbus, Ontario Co., *C. Williams* 219; Highway 7 & Indian R., Peterborough Co., *C. Williams* 216; Stayner, Simcoe Co., *Williams* 1610; Emily Twp., Victoria Co., *C. Williams* 217; Morriston, Wellington Co., *C. Williams* 237; Jct. Highways 400 & 7. York Co., *Williams* 1395.

MEXICO. BAJA CALIFORNIA: Los Cedros I., *Steere* 17532, 17536.

UNITED STATES. TEXAS: San Marcos, Hays Co., *Wright* (Sull. & Lesq., *Musci Bor.-Amer.* 117: isotype of *P. texana* Wareham); Laredo, Webb Co., *Orcutt* 5565, 5567.

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A CONTRIBUTION TO THE BRYOLOGY OF THE SOUTHERN UNITED STATES

WILLIAM D. REESE[1]

The gulf coast region of the southern United States is still a relatively fertile area for the field bryologist to work, as can be noted from a number of recent papers reporting range extensions of various species of mosses within the area (Breen & Pursell, 1959; Crum & Anderson, 1960; Pursell *et al.*, 1956; Pursell, 1958; Reese, 1956, 1959). Large parts of the region have remained inadequately examined for bryophytes by not having resident bryologists to collect there, and the unwholesome aspect of some of the habitats, notably the dark cypress-gum swamps, has apparently led to their neglect as collecting sites. Thus it may be quite rewarding, botanically speaking, to collect along the gulf coast, especially if the less accessible swamps and bayou margins are searched,

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as well as the infrequent elevations of the region such as escarpments, river bluffs, and salt domes. Most of the range extensions reported here are westward extensions of more or less eastern mosses or of species previously known only from Florida. These extensions of range are in keeping with the general character of the bryophyte flora of the gulf coast which is more or less the same as far west as the "Big Thicket" area of eastern Texas. As the gulf coast flora becomes better known, especially that of the central part in Alabama, Mississippi, Louisiana, and Texas, we may expect to find still more "Floridian" or eastern species having a general distribution throughout the area. It is germane to mention here the recent discovery of *Psilotum nudum* in cypress swamps in southern Louisiana and eastern Texas (Reese, 1960, 1961), which places the known distribution of the species in the United States in accord with that of many other gulf coast plants.

The purpose of this contribution is to publish records of range extension for the following 10 species of mosses, all of which represent new state records and one of which is new to the United States. Specimens of all collections are deposited in the herbarium of the University of Southwestern Louisiana; duplicates of most of them have been distributed to various other herbaria.

Callicostella pallida (Hornsch.) Ångstr. LOUISIANA, IBERIA PARISH: On the upper side of a fallen *Fomes* lying on the ground in rich, shady woods near a ravine, N. side of Weeks Island, 8 April 1958, *W. D. Reese* 1780; abundant on a rotted stump, steep hillside in dense woods, Weeks Island, 5 Oct. 1958, *W. D. Reese* 1875 (*c.fr.*),—Weeks Island, the site of the above collections, is an unusual collecting site and merits special attention. The "island" is one of a series of salt domes in south-central Louisiana which are emergent, up to ca. 150 ft., above the surrounding marshlands. These domes are of particular interest botanically since they offer a variety of habitats not otherwise afforded by the area and consequently support a flora which is strikingly different from that of the Louisiana gulf coast in general. Some of the trees found on Weeks Island, for example, include *Aesculus pavia* L., *Ilex opaca* Ait., *Magnolia grandiflora* L., *Prunus caroliniana* Mill., *Quercus prinus* L., and *Ulmus rubra* Muhl., while in the deep, cool, shady ravines of the island are to be found a number of ferns among which are *Athyrium pycnocarpon* (Spreng.) Tidest., *Diplazium lonchophyllum* Kunze, *Polystichum acrostichoides* (Michx.) Schott, and *Pteris cretica* L. In addition to *Callicostella* as a novelty on Weeks Island, *Solmsiella kurzii* Steere, known otherwise from only one locality in north-central Florida, has been found there (Pursell,

1958). Other mosses of interest include *Syrrhopodon parasiticus* (Sw.) Besch., *Herpetineurum toccoae* (Sull. & Lesq.) Card., *Anacamptodon splachnoides* (Froel.) Brid., *Papillaria nigrescens* (Hedw.) Jaeg., *Pireella pohlii* (Schwaegr.) Card., *Fissidens hallii* Aust., *F. kegelianus* C.M., *F. subbasilaris* Hedw., and *F. pellucidus* Hornsch. These collections of *Callicostella* are the first to be reported for the U. S. outside of Florida.

Campylopus arctocarpus (Hornsch.) Mitt. FLORIDA, FRANKLIN CO.: Cypress bayhead or small cypress swamp, 19.8 mi. N. of junction of highways 98 and 65, 4.5 miles S. of Sumatra on highway 65, on dead cypress stumps, 2 April 1956, *Dennis Hynes* 4-256-1.7 (determined by H. Crum and L. E. Anderson). LIBERTY CO.: On old stumps and on humus at bases of cypress trees, cypress swamp, W. side of Fla. 65, 8 mi. S. of Hosford, 24 July 1957, *W. D. Reese* & *R. K. Godfrey* 1348.—While looking over a collection of bryophytes made by Dennis Hynes in connection with his studies of crane-fly larvae, I came across a *Campylopus*, subg. PALINOCRASPIS, which I could not identify. Correspondence with Mr. E. B. Bartram and Dr. Howard Crum eventually established the identity of the species as *C. arctocarpus*, new to the United States. The species is otherwise known from Mexico, Central America, Jamaica, Dominica, and eastern South America. I have since looked for this moss in cypress swamps all along the central part of the gulf coast, but without success except in the region adjacent to Hynes' original site in the eastern "Panhandle" region of Florida.

Fissidens pellucidus Hornsch. LOUISIANA, IBERIA PARISH: At base of *Liquidambar* at edge of woods, Weeks Island (salt dome), 14 Nov. 1959, *W. D. Reese* 2596.—This little moss is probably much more widely distributed in the southern states than published records indicate. In the U. S., outside of Louisiana, the species has been reported from Georgia and Florida.

F. reesei Crum & Anderson. LOUISIANA, ST. MARTIN PARISH: On bases of cypress trees between buttresses, beside a small stream and subject to flooding, low area at base of bluff along parish line, ca. 4.5 mi. NW. of St. Martinville, 4 June 1960, *W. D. Reese* 2720. TERREBONNE PARISH: At base of a cypress tree and subject to inundation, cypress-gum swamp along N. side of Gibson-Schriever road ca. 1.3 mi. E. of jct. with U.S. 90, 23 Jan. 1960, *W. D. Reese* 2589 (determination verified by H. Crum).—Only recently described from Florida, this little moss was found in abundance at the stations cited above. It is evidently a plant of swamps, seeming to prefer the bases of cypress trees which are subject to periodic

flooding, and will doubtless come to be known from the coastal regions of Alabama, Mississippi, and eastern Texas.

F. subbasilaris Hedw. LOUISIANA, IBERIA PARISH: On the side of a leaning magnolia, deep woods, Weeks Island, ca. 14 mi. S. of New Iberia, 4 Aug. 1958, *W. D. Reese* 1846. TEXAS, HARDIN CO.: Near base of magnolia, dry oak-hickory forest, running into beech-magnolia on slopes, vic. of Bracken Cemetery, ca. 1 mi. SW. of Honey Island, 8-10 June 1959, *W.D. Reese* & *R. A. Pursell* 2232.—The Texas collection confirms Dr. Whitehouse's statement (1954, p. 70) that this species "may be expected in Texas." It does not seem to have been reported from Louisiana previously.

Haplohymenium triste (Ces.) Kindb. TEXAS, TYLER CO.: On bark of *Fagus* in open beech-magnolia stand along Little Cypress Creek, ca. 2.5 mi. W. of Woodville on U.S. 190, 10 June 1959, *R. A. Pursell* & *W. D. Reese* 3696.—This species occurs widely although often sparingly in the U.S., and its presence in eastern Texas is not surprising. The original of this collection is in Dr. Pursell's herbarium.

Leskea arenicola Best. TEXAS, HARDIN CO.: On exposed pine root, beech-magnolia forest, W. side of U.S. 96, ca. 5 mi. S. of Silsbee, vic. of S. bank of Village Creek, 8-10 June 1959, *W. D. Reese* & *R. A. Pursell* 2206.—The species has been reported from Louisiana (Williams, 1927), and its discovery in Texas is not too surprising. However, the species must be rather rare in the South since it is not known otherwise from south of Virginia.

Macromitrium richardii Schwaegr. LOUISIANA, ST. TAMMANY PARISH: On smooth bark of a fallen branch of *Betula nigra*, low woods along La. 21, ca. 5 mi. NE. of Covington, 29 Apr. 1959, *W. D. Reese* 2092.—This species, reported here for the first time in the U.S. outside of Florida, was collected in a region of Louisiana known as the "Florida Parishes." The vascular flora, at least, of this area is dissimilar to that of the rest of the state and is more closely allied to that along the gulf coast to the east.

Ptychomitrium serratum BSG. LOUISIANA, RAPIDES PARISH: In a crevice on a concrete dam on Indian Creek, vic. of State Fish Hatchery, Beechwood State Forest, ca. 5 mi. NW. of Lecompte, 26 Mar. 1959, *W. D. Reese* 1990 (determination verified by H. Crum).—The presence of this moss at a site so remote from its only other known stations in the U.S. (Culberson Co., in extreme western Texas) seems at present to be inexplicable not only in the light of the distance between the two localities (ca. 700 mi.) but also in

view of the differences in climate (*e.g.* 10-18 in. annual rainfall in Culberson Co., Tex.; 56 in. in Rapides Parish, La.). It is always possible of course that the species will be found more widely in Texas, in which case the Louisiana find would not be so surprising. Certainly the few rock exposures in the western part of Louisiana will bear careful examination. The species is otherwise known from Mexico and Guatemala.

Thuidium allenii Aust. TEXAS, HARDIN CO.: On damp soil in beech-magnolia forest, S. bank of Village Creek, ca. 5 mi. S. of Silsbee, on U.S. 96, 8-10 June 1959, *W. D. Reese* & *R. A. Pursell* 2201 (determined by A. J. Sharp).—The collection marks a not surprising extension of range for this primarily southeastern species.

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LOUISIANA HEPATICOLOGY. 1. A LIST OF SPECIES

LEO F. KOCH[1]

During the school year, 1954-55, while a visiting professor at Tulane University, I systematically reviewed the bryological literature of the state of Louisiana. The muscological results were summarized and partly published some time ago (Koch, 1956). The botanists who collected mosses in Louisiana during the nineteenth century and were mentioned in that paper, notably THOMAS DRUMMOND, AMERICUS FEATHERMAN, CHARLES MOHR, and the REV. A. B. LANGLOIS, also collected liverworts. Later collectors

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were RUTH D. SVIHLA, BROTHER NEON, and DONOVAN S. and HELEN B. CORRELL. FAITH PENNEBAKER MACKANESS collected, identified, and curated the specimens which now form the bulk of the hepatic herbarium at Tulane University, and hers is doubtlessly the most important single contribution to Louisiana hepaticology.

Among the noted hepaticologists who studied, identified, and published on the bulk of the earlier collections from Louisiana are ALEXANDER EVANS, MARSHALL A. HOWE, and L. M. UNDERWOOD. All the earlier contributions were tabulated by T. C. Frye and Lois Clark (1937-47); they designated 65 species as having been collected in Louisiana. Since then, only miscellaneous lists of species from specific localities or in certain genera have appeared in the literature. For that reason, it is hoped that a comprehensive list of species of hepatics reported from Louisiana may be useful. The arrangement of families in the following list follows that of Evans (1939).

Anthocerotaceae

Anthoceros carolinianus Mx.
A. laevis L.
A. meridionalis St.
A. punctatus L.
A. ravenelii Aust.
Notothylas breutelii Gottsche
N. orbicularis (Schwein) Sull.

Lepidoziaceae

Bazzania trilobata (L.) S. F. Gray
Microlepidozia sylvatica (Evans) Joerg.
Telaranea nematodes (Gottsche) M. A. Howe

Calypogeiaceae

Calypogeia fissa (L.) Raddi
C. trichomanis (L.) Corda

Cephaloziaceae

Cephalozia catenulata (Hüb.) Spruce
C. macounii Aust.
C. macrostachya Kaal.
C. media Lindb.
Odontoschisma denudatum (Mart.) Dum.
O. macounii (Aust.) Underw.
O. prostratum (Sw.) Trev.
O. sphagni (Dicks.) Dum.

Cephaloziellaceae

Cephaloziella rhizantha (Mont.) Schust.
C. rubella (Nees) Dum.

Harpanthaceae

Chiloscyphus polyanthus (L.) Corda
Clasmatocolea exigua St.
Lophocolea heterophylla (Schrad.) Dum.

Jungermanniaceae

Gymnocolea inflata (Huds.) Dum.
Jamesoniella autumnalis (DC.) St.
Plectocolea crenulata (Sm.) Evans

Plagiochilaceae

Plagiochila ludoviciana Sull.
P. undata Sull.

Scapaniaceae

Scapania nemorosa (L.) Dum.

Porellaceae

Porella bolanderi (Aust.) Pears.
P. pinnata L.
P. platyphylla (L.) Lindb.
P. platyphylloidea (Schwein.) Lindb.
P. swartziana (Web.) Trev.

Radulaceae

Radula andicola St.
R. australis Aust.
R. bolanderi Gottsche
R. caloosiensis Aust.
R. complanata (L.) Dum.
R. langloisii Castle
R. obconica Sull.
R. sullivantii Aust.

Frullaniaceae

Frullania brittoniae Evans
F. donnellii Aust.
F. inflata Gottsche
F. kunzei Lehm. & Lindenb.
F. obcordata Lehm. & Lindenb.
F. riparia Hampe
F. squarrosa (R. Bl. & N.) Dum.

Lejuneaceae

Ceratolejeunea guianensis (Nees & Mont.) St.
Cololejeunea biddlecomiae (Aust.) Evans
C. minutissima (Sm.) Schiffn.
C. setiloba Evans
Enosmolejeunea clausa (Nees & Mont.) Evans
E. duriuscula (Nees) Evans
Lejeunea cavifolia (Ehrh.) Lindb.
L. cladogyna Evans
L. flava (Sw.) Nees
L. glaucescens Gottsche
L. minutiloba Evans
Leptocolea cardiocarpa (Mont.) Evans
Leucolejeunea clypeata (Schwein.) Evans
L. conchifolia Evans
L. unciloba (Lindenb.) Evans
Mastigolejeunea auriculata (Hook. & Wils.) Schiffn.
Microlejeunea cardotii (St.) Evans
M. lactevirens (Nees & Mont.) Evans
M. ruthei Evans
M. ulicina (Tayl.) Evans
Rectolejeunea maxonii Evans
R. phyllobola (Nees & Mont.) Evans
Stylolejeunea spiniloba (Lindenb. & Gottsche) Evans

Fossombroniaceae

Fossombronia foveolata Lindb.

Pelliaceae

Pellia fabroniana Raddi

Pallaviciniaceae

Pallavicinia lyellii (Hook.) S. F. Gray

Metzgeriaceae

Metzgeria angusta St.
M. ciliifera Schwein.
M. conjugata Lindb.

Riccardiaceae

Riccardia latifrons Lindb.
R. multifida (L.) S. F. Gray
R. palmata (Hedw.) Carr.
R. pinguis (L.) S. F. Gray
R. sinuata (Dum.) Trev.

Marchantiaceae

Conocephalum conicum (L.) Dum.
Dumortiera hirsuta (Sw.) Nees
D. nepalensis (Tayl.) Nees
Marchantia domingensis Lehm. & Lindenb.
M. polymorpha L.

Rebouliaceae

Asterella tenella (L.) P-Beauv.
Reboulia hemisphaerica (L.) Raddi

Corsiniaceae

Corsinia coriandrina (Spreng.) Lindb.

Ricciaceae

Riccia albida Sull.
R. arvensis Aust.
R. austinii St.
R. crystallina L.
R. fluitans L.
R. frostii Aust.
R. glauca L.
R. hirta Aust.
R. mcallisteri Howe
R. membranacea Gottsche & Lindenb.
R. sullivantii Aust.
Ricciocarpus natans (L.) Corda

Sphaerocarpaceae

Sphaerocarpus donnellii Aust.
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REAPPEARANCE OF RIELLA AMERICANA IN TEXAS

DANA G. GRIFFIN III[1]

Riella americana Howe. & Underw., an hepatic well known for the peculiarities of its anatomy and rated by bryologists as quite rare, has been collected *en masse* from a playa lake in northwest Texas during September, 1960. Studhalter (1932) reported collecting the same species from a similar situation in the same county in the early 1930's, but his data were too vague for the exact location to be ascertained.

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There are at present no major lake basins in the Panhandle and South Plains region of the state, but rain can and does collect in numerous of the locally depressed areas, forming "playa lakes." At such a lake, 13.5 miles east and 10 miles north of Lubbock, Lubbock Co., approximately 15 gallons of almost pure material were collected on October 11, 1960. The lake, about 2 acres in area, was typically shallow (not more than 3 feet deep) and rapidly filling with silt and other soil being blown into it by the strong, seemingly unceasing autumn winds which race across it from the neighboring agricultural lands. At the margin of the lake where the water line was receding, a green ribbon of *R. americana*, two feet wide, stretched for nearly three-quarters of a mile!

At the present time, a satisfactory explanation for the overwhelming appearance of the hepatic in this one lake is not at hand. Another playa less than one-quarter of a mile away, when investigated, did not show a single gametophyte, nor did 25 other such lakes within a 15-mile radius of the productive playa lake.

It might also be noted that Dr. Vernon W. Proctor collected gametophytes with sporophytes at Laguna Huerfana, San Miguel Co., New Mexico, in May of 1959. As far as I know, *R. americana* has never been reported from that state; the collection (*Proctor* .0001) is deposited in the herbarium of Texas Technological College.

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DISPERSAL OF RIELLA SPORES BY WATERFOWL

VERNON W. PROCTOR[1]

The first collections of *Riella americana*, the submerged aquatic liverwort, as well as those from more recent years, have been from western Texas and adjacent New Mexico (Howe & Underwood, 1903; Studhalter, 1932; Griffin, 1961). Within its range the plant is considered rare. No explanation has been suggested for its limited distribution. The possibility that it is merely apparent because of the small number of trained observers in the area cannot be ruled out completely, but two general conjectures seem more likely: *R. americana* may require some particular set of environmental conditions unique to a few bodies of water, or it may lack

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an efficient means of dispersal. An investigation of the latter point was made possible by the recent discovery of large masses of *Riella* in a playa north of Lubbock.

An examination of plants from this playa on October 9, 1960 revealed large numbers of sporophytes many of which were filled with brown and apparently mature spores. Several liters of the plant material were collected from the shores of the playa and brought to Lubbock. After the plants had been rinsed briefly with tap water, several handfuls were presented in water to a pen of three domesticated mallard ducks (one male and two females). The plants were promptly consumed. Twenty minutes later the ducks were removed from the feeding pen and washed in a tub of fresh water. Particular attention was paid to the feet, bill, and anal region of each. The ducks were not particularly upset by these proceedings. They had been employed throughout much of the preceding four months in a similar study of *Chara* dispersal. After the birds had been washed, they were placed in a second elevated pen with a wire mesh bottom where mixed grain and water were available. Thirty minutes later the accumulated feces were removed from a tray below the pen, washed, and labeled lot I. It was clear from an examination of this material that a large number of spores had passed through the ducks. No intact sporophytes were observed. Most spore masses had separated as individual cells. The spores appeared normal under the microscope; they were not crushed, and the characteristic markings on the spore walls were still intact. A careful search for vegetative cells revealed recognizable bits of thalli and gemmae, but all were obviously dead.

On the second day the feeding experiment was repeated in exactly the same manner as that described above, including the use of freshly collected *Riella* plants. The results were similar. Tens of thousands of spores were collected (lot II). The following day the ducks were again fed and treated in the usual manner, except that this time the droppings were collected individually from the ducks. Spores were abundant in the feces from the male (lot IIIa) and one female (lot IIIb), but not from the second female.

The four lots of spores (I, II, IIIa, and IIIb) were allowed to stand seven days, with frequent changes of water during this period. At the end of one week each lot was divided into seven parts and treated as follows: *A*. Stored in water (ice) at −10°C. *B*. Stored in water at 1°C. *C*. Stored in water at 24°C. *D*. Stored in water at 37°C. *E*. Dried on cover glasses and stored at −10°C. *F*. Dried on cover glasses and stored at 24°C. *G*. Dried on cover glasses and stored at 37°C. All spores were left in complete darkness under these conditions for 60 days.

By the end of this 60-day period approximately one-fourth to one-half the spores in treatment C of lots I and II had already germinated and produced small germlings 0.5-0.8 cm. tall. At this time the remaining spores were inoculated into sterile tubes of soil and water. Spores that had been stored in water were washed for three minutes in a hypochlorite solution ("Chlorox" 1:20) before inoculation. No attempt was made to remove the spores that had been dried on cover slips; the glass was simply broken and the fragments dropped into the tubes of soil and water. All inoculated tubes were placed in a light room at 24°C. Two weeks later all tubes were checked for germination. Results are shown in TABLE 1.

TABLE 1. Germination of *Riella* spores after passage through ducks. Each estimate is based on the germination in ten tubes: +++ 30% or greater germination; ++ 10-30% germination; + less than 10% germination; − no germination.

TREATMENT[1]	LOTS[1]			
	I	II	IIIa	IIIb
A	++	+	−−−[2]	−−−[2]
B	+++	+++	+++	+++
C	+++[3]	+++[3]	+	+
D	+++	+++	+++	+++
E	−	+	++	++
F	+++	+++	−−−[2]	−−−[2]
G	+++	+++	−−−[2]	−−−[2]

[1] See text for details.
[2] Insufficient spores for test.
[3] Spores germinated in darkness, before inoculation.

The germination and subsequent development of the germlings from spores that had passed through the ducks seemed normal in every respect. Moreover, the percentage of spores that germinated was as great as that in cultures inoculated with spores collected directly from the playa or from laboratory cultures. Since many ducks and other water birds migrate through the Texas panhandle during early autumn, at a time when *Riella* plants bear ripe spores, it seems reasonable to suppose that large numbers of viable spores must be carried to other bodies of water nearby. The fact that these plants fail to materialize or at any rate never become abundant in neighboring ponds and playas in following years suggests that the ecological conditions associated with most lakes are unfavorable either for the germination or, as seems more likely, for the survival and multiplication of developing germlings. Some of

the latter aspects of this problem are currently under investigation in this department.

Doubtlessly some *Riella* spores also are carried externally on the feet and feathers of birds as suggested by Studhalter (1931) and Persson and Imam (1960). This method might be particularly effective in transporting spores over long distances. For distances of 50 miles or less a great many more spores are probably carried internally (Proctor, 1959). In either case the conclusion seems warranted that an adequate means of dispersal does exist and that the explanation for the rarity of this interesting little plant therefore must be sought elsewhere.

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THE FONTINALACEAE: A BRIEF SUMMARY

Winona H. Welch[1]

Following Cardot's "Monographie des Fontinalacées" of 1892, the family has been treated by most authors as consisting of the six genera, *Fontinalis*, *Dichelyma*, *Brachelyma*, *Wardia*, *Hydropogon*, and *Hydropogonella*. After carefully examining a large number of specimens represented in European and American herbaria, including the types of nearly all of the known species, the present author concluded that *Wardia*, *Hydropogon*, *and Hydropogonella* do not form a natural alliance with *Fontinalis*, *Dichelyma*, and *Brachelyma*. A significant difference appears in the character of the peristome. The trellis-like inner portion of the peristome is conspicuous and well developed in *Fontinalis*, *Dichelyma*, and *Brachelyma*, but lacking in *Wardia*, *Hydropogon*, and *Hydropogo-*

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nella. In addition to the marked contrasts in peristome characters, there are many other outstanding differences, too numerous to include in this paper. They have been discussed in detail in *The Bryologist* (1943) 46: 25-46 in a study made by this author regarding "The systematic position of the genera *Wardia, Hydropogon*, and *Hydropogonella*."

On the exclusion of these three genera from the Fontinalaceae and in the absence of any family to which they are closely related, it was necessary to establish new families to include them. The characteristics of *Wardia* are sufficiently different from those of *Hydropogon* and *Hydropogonella* to constitute a family to itself, and so the new family Wardiaceae was described. *Hydropogon* and *Hydropogonella* are obviously members of the same category and were therefore included in the family Hydropogonaceae, also described as new. The original descriptions of the Wardiaceae and Hydropogonaceae were published in volume 46 of *The Bryologist*, in a monographic treatment of *Wardia hygrometrica* Harv. & Hook., *Hydropogon fontinaloides* (Hook.) Brid., and *Hydropogonella gymnostoma* (Bruch & Schimp.) Card.

The diagnostic characteristics of the Fontinalaceae are as follows: plants aquatic, attached at base; stems irregularly pinnately divided; leaves tristichous; peristome double, the outer consisting of 16 teeth, the inner of 16 cilia, free or incompletely to completely united by transverse strands into a cone-like trellis.

In 1934, a monographic treatment of the Fontinalaceae of the United States and Canada was published by the author in A. J. Grout's *Moss Flora of North America North of Mexico*. This study served as a basis for a world monograph.

Acknowledging the fact that characteristics of the fruits are more stable than those of the vegetative parts of plants, the author has used largely the gametophytic characteristics for separating the genera and for distinguishing the species and varieties within the genera because, *first*, the plants in this family frequently are not collected in fruit; *second*, the fruits of some species and varieties are unknown; and, *third*, differences in the sporophytes within the genera occur only in a few species and varieties. The anatomy of the stem, as observed in cross-sections, is fundamentally in accord throughout the family, a central area of parenchymatous cells surrounded by several layers of sclerenchyma.

The plants of *Fontinalis*, especially the younger growth, appear to be modified rather easily by environmental conditions, such as still water, running water, drought, and calcium deposit on leaves and branches.

On the same plant, the shape of the blade and the length-width

ratio of the leaf and of the median cells frequently vary in leaves from younger portion of axes and those from median locations; auricles may be distinct in mature leaves and lacking or slight in the blades on young axes; leaf bases may be decurrent in median cauline leaves and not decurrent in the younger leaves; in the carinate-conduplicate group, frequently the younger leaves and occasionally the median branch leaves are plane, and the median cauline blades are keeled-conduplicate, and the keels are distinctly curved in the mature leaves and straight in the younger blades; and frequently three different kinds of leaves occur, roughly classified as those near the base of the axes, those near the tips of the axes, and those in the median portion of the stems and branches. Upon the basis of the confusion of characteristics enumerated, two methods of classifying the plants in this family appear possible: *first*, the use of species or varieties for each variation which occurs, either genetic or ecological, and, *second*, the selection of one or more parts which seem to be rather stabilized throughout the Fontinalaceae and yet show sufficient differentiation for the recognition of the species and varieties. It appears to the author that the making of new species, varieties, or forms based on plants or portions of plants which differ only because of environmental conditions may only increase the confusion which already exists in the classification of plants belonging to *Fontinalis*. In the monographic study of the Fontinalaceae, the median cauline leaves in all instances, and the perichaetial leaves and sporophytes, if present, have been used as the basis of determination.

The leaves of *Brachelyma* and *Dichelyma* are costate and always carinate-conduplicate. In *Fontinalis* the leaves are ecostate and vary from plane to concave, tubular, or carinate-conduplicate. Additional outstanding characteristics of *Brachelyma* include the conspicuously three-angled ends of the foliated stems and branches and a completely immersed capsule. Those of *Dichelyma* comprise the secund and falcate leaves and the calyptra enveloping the capsule which varies from emergent to surpassing the perichaetium.

The species and varieties of *Fontinalis* may be divided into three groups, based upon the majority of the median leaves of the stems: (1) blades carinate to carinate-conduplicate, (2) blades concave, and (3) blades plane. In the first group, the species are largely distinguished upon the bases of the curvature of the keels or median lines, the symmetry or asymmetry of the shape of the blades, the size and the length-width ratio of the leaves, the position of the greatest curvature of the keel and width of the blade, and the shape of the leaves. In the second group, the chief differences include the involution of the leaf margins, sudden or gradual de-

crease in cell width toward the leaf margins, the shape and size of the blades, and whether or not the leaf apices are plane, concave, canaliculate, tubular, or carinate. The species in the third group are separated especially upon the bases of the shape and size of the leaves, the position of greatest width of the blades, and the differences in leaf auricles.

The family, Fontinalaceae, consists of three genera, *Fontinalis*, *Dichelyma*, and *Brachelyma*, with a total of 27 species and 9 varieties: *Fontinalis*, 20 species and 9 varieties; *Dichelyma*, 5 species; and *Brachelyma*, 2 species. The known distribution is as follows: AFRICA 4—*Fontinalis*, 3 species, 1 variety. ASIA 6—*Dichelyma*, 2 species; *Fontinalis*, 3 species, 1 variety. EUROPE 12—*Dichelyma*, 2 species; *Fontinalis*, 6 species, 4 varieties. NORTH AMERICA 29—*Brachelyma*, 2 species; *Dichelyma*, 4 species; *Fontinalis*, 17 species, 6 varieties. SOUTH AMERICA 4—*Fontinalis*, 4 species. The species with greatest range of distribution (occurring in three or more of the five areas) are *Dichelyma falcatum* (Asia, Europe, and North America), *Fontinalis antipyretica* (Africa, Asia, Europe, and North America), *F. antipyretica* var. *gigantea* (Africa, Europe, and North America), *F. duriaei* (Africa, Asia, Europe, North America, and South America), and *F. hypnoides* (Asia, Europe, and North America). *Dichelyma capillaceum* is known to occur in Europe and North America, *Fontinalis antipyretica* var. *gracilis* in Asia and Europe, *F. dalecarlica* in Europe and North America, and *F. squamosa* in Africa and Europe.

THE OCCURRENCE OF BRYUM CORONATUM IN MICHIGAN[1]

NARINDER CHOPRA[2] & A. J. SHARP[3]

Bryum coronatum was described from Guiana and Jamaica by Schwaegrichen (1816) but is known to have a rather wide distribution in the warmer parts of the world (Brotherus, 1924; Crum, 1951). In the United States it has been reported only from Florida (Andrews, 1935-40; Schornherst, 1940, 1943).

While at the University of Michigan Biological Station the authors in late June 1959 visited limestone sink no. 4S2 of the series whose bryophyte flora was studied by Robinson and Wells

[1] Contribution from the Botanical Laboratory, University of Tennessee, N. Ser. 220, and the University of Michigan Biological Station.

[2] Deceased December 31, 1960.

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(1956). On a moist, calcareous ledge of a wall of the sink a *Bryum* was collected, in fruit, by the senior author. This was soon identified as *B. coronatum*, and later Dr. A. L. Andrews kindly confirmed this determination. Although the Michigan plants have slightly smaller leaves and somewhat smaller leaf cells than the material from other parts of the world, the differences seem to be too slight to be significant.

We believe that this collection represents not only an extension of range of nearly 1000 miles to the north in North America and the first record of *B. coronatum* in Michigan but also the first report of it from a cool temperate area. For mapping purposes, the sinks are located in northern Alpena County. An explanation of its occurrence there awaits further study.

Exsiccati (no. 141) of this material are deposited at the University of Tennessee and the University of Michigan and in the herbarium of Dr. A. L. Andrews.

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AN EXTENSION OF RANGE OF BARBULA AGRARIA

Edward C. Taylor, Sr.[1]

Barbula agraria Hedw. is common in tropical America including Florida but as far as I can find has not been reported north of that state. It may therefore be of interest to report two collections of this moss, in good fruiting condition, from Dorchester County, South Carolina. (Determinations were made by Dr. H. S. Conard.)

[1] Hillside Rd., Woodstock, Vt.

The first collection was made by the writer on tabby walls of the ruins of Fort Dorchester, about five miles southeast of Summerville, between that place and Charleston. The fort was built around 1775. Tabby is made of oyster shells and burnt shell lime, thereby giving the habitat this moss apparently needs. The second collection was made later at the same place, following the writer's suggestion, by Edmund R. Cuthbert, Jr., curator of the Cuthbert Museum at Summerville.

The interesting thing about the second collection is that among a hundred or so plants there were ten in which two setae (never more) were growing from the same perichaetium. No plants with double setae appeared in the first collection. In these ten mosses the two setae were mostly of the same stage of development, but in some plants one seta appeared much younger or less developed than the other.

A third South Carolina collection on tabby has since been made by Mr. Cuthbert at Hiltonhead Island, Beaufort Co.; this collection, also named by Dr. Conard, shows only single setae.

ADDITIONS TO THE MOSS FLORA OF SHENANDOAH NATIONAL PARK, VIRGINIA

ROBERT R. IRELAND, JR.[1]

During the last three years I have found a total of 32 mosses in Shenandoah National Park, Virginia, that were previously unreported by other botanists who had collected in the Park, Schnooberger and Wynne (1945), Patterson (1955), Prior (1959), and Hermann (1959). The Park flora, which is comprised predominantly of northern species, now totals 232 mosses.

Eleven species and varieties new to Virginia are marked by asterisks. If reported previously for the state, county records of taxa are given in parentheses. All specimens cited are deposited in the United States National Herbarium.

Andreaea rupestris Hedw. PAGE Co.: On exposed rock at summit of Stony Man Mt., alt. 4000 ft., 621; mixed with *A. rothii* on rock in oak woods near Crescent Rock Overlook, alt. 3500 ft., 2116; on rock at summit of Hawksbill Mt., alt. 4000 ft., 2260. RAPPAHANNOCK Co.: On rock ledge near Browntown Valley Overlook, alt. 3000 ft., 693. (GILES and SMYTH).

Aphanorhegma serratum (Hook. & Wils.) Sull. MADISON Co.: On soil along trail in oak woods, Cedar Run Trail, alt. 1500 ft., 1933; mixed with

[1] Smithsonian Institution, Washington 25, D. C. I am grateful to Dr. Seville Flowers for his help with a problematic *Philonotis*, and to Dr. Howard Crum for determining or verifying many of the collections.

Physcomitrium pyriforme along trail at base of Old Rag Mt., alt. 2000 ft., 2413. (FAIRFAX and GILES).

Astomum muehlenbergianum (Sw.) Grout. PAGE CO.: On soil along roadside at mile 22 near Rattlesnake Point Overlook, alt. 3000 ft., 3759. (BOTETOURT, ROANOKE, ROCKBRIDGE, and SPOTSYLVANIA).

**Atrichum undulatum* var. *altecristatum* Ren. & Card. MADISON CO.: On humus mixed with *Rhynchostegium serrulatum* along trail to Old Rag Mt., alt. 2000-3200 ft., 2405. The only character that distinguishes this variety from typical var. *undulatum* is the height of the lamellae. The lamellae are low, 2-6 cells high, in var. *undulatum*, but are somewhat higher, 6-9 cells high, in var. *altecristatum*. Whether the lamellae height is a useful criterion in delimiting species and varieties in the genus *Atrichum* is somewhat dubious, since it varies so greatly from one leaf to another on the same plant. Frye (1949) felt that this variety is not clearly distinct from var. *undulatum*, and I am inclined to agree.

**Brachythecium populeum* (Hedw.) BSG. MADISON CO.: On rock at base of last falls of Whiteoak Canyon, alt. 1400-2500 ft., 2101. PAGE CO.: On rock along trail to summit of Stony Man Mt., alt. 3500-4000 ft., 583, 593, 595; on rock along trail to summit of Hawksbill Mt., alt. 3600-4000 ft., 2235. WARREN CO.: On dry rock in oak-hickory woods, Dickey Hill Trail, alt. 2200-2500 ft., 1808; on dry rock in oak-hickory woods along trail to Compton Mt., alt. 2400-2900 ft., 1845. This is an easily recognized species when the characters of the costa and the seta are considered together. The costa nearly reaches the leaf apex in many of the branch leaves, while the seta is rough above and smooth below. This northern moss reaches its southernmost extension in North Carolina, according to Grout (1928).

**Brachythecium reflexum* (Starke) BSG. PAGE CO.: On rock in woods near Tanners Ridge Overlook, alt. 3500 ft., 2277. The range of this northern species is extended farther southward from Garrett County, Maryland, where, according to Jennings (1951), J. D. Smith collected it. It probably occurs even farther south in the mountains to North Carolina and Tennessee.

Dicranum fulvum var. *viride* (Sull. & Lesq.) Grout. PAGE CO.: On base of tree along trail to summit of Stony Man Mt., alt. 3500-4000 ft., 590. (GILES and SMYTH).

Dicranum spurium Hedw. AUGUSTA CO.: On sandy soil near Park boundary along road to Crimora Lake, alt. 1500-2200 ft., 2322. (GILES, SMYTH, and SPOTSYLVANIA).

**Fissidens bushii* Card. & Thér. MADISON CO.: On soil at base of Old Rag Mt., alt. 2000 ft., 2385, 2414. RAPPAHANNOCK CO.: On soil along trail at top of Little Devils Stairs, alt. 2000-2700 ft., 2531, 2536. WARREN CO.: On soil in oak-hickory woods along Dickey Hill Trail, alt. 2200-2500 ft., 1811. This moss is very similar to *F. taxifolius* and has undoubtedly been confused with it. They may be distinguished by the costa, which ends in the leaf apex in *F. bushii*, but extends into a short mucro in *F. taxifolius*. The occurrence of this *Fissidens* in the state was fully expected, since Virginia lies near the center of its known distribution.

Funaria hygrometrica Hedw. MADISON CO.: On soil mixed with *Ceratodon purpureus* and *Barbula unguiculata*, at top of trail to Dark Hollow Falls, alt. 3400 ft., 1980. (ALBEMARLE, GILES, NORFOLK, PRINCESS ANNE, ROANOKE, SMYTH, AND SPOTSYLVANIA).

Grimmia olneyi Sull. MADISON CO.: Abundant on rock outcrop near last falls, along Whiteoak Canyon Trail, alt. 1400-2500 ft., 2105. (FAIRFAX and SMYTH).

**Homalia gracilis* James. *H. jamesii* var. *gracilis* (James) Wagner. WARREN CO.: On rock ledge under overhanging rocks at Overall Run Falls, alt. 1500 ft., 2502. Only a small portion of this sterile moss was found growing with *Anomodon attenuatus* on a wet rock ledge that was in the constant spray of a waterfall. This species has sometimes been regarded as a variety of *H. jamesii*, but there seems to be a sufficient number of taxonomic characters for it to remain a separate species. *Homalia gracilis* is separated from *H. jamesii* by its small size, its extremely short costa (which in most leaves is usually split), and by its many flagelliform branches. In addition, *H. gracilis* has a specific habitat preference, occurring most often on wet rock ledges under overhanging rocks. Wagner (1952) reported this moss "to be confined to an area extending from the Adirondack Mountains of New York eastward into Vermont." Recently, however, Pursell and Sharp (1959) have reported it from Tennessee.

Homalotheciella subcapillata (Hedw.) Card. MADISON CO.: On trunk of dead oak near falls of Whiteoak Canyon, alt. 1400-2500 ft., 2097. WARREN CO.: Mixed with *Anomodon minor* on trunk of oak along Overall Run Trail, alt. 1500-2300 ft., 2460. (BOTETOURT, ESSEX, HENRICO, HENRY, MECKLENBURG, MIDDLESEX, PRINCESS ANNE, SMYTH, AND WYTHE).

Hypnum cupressiforme var. *filiforme* Hedw. PAGE CO.: On large tree trunk along trail to summit of Stony Man Mt., alt. 3500-4000 ft., 3665. (GILES).

**Hypnum cupressiforme* var. *subjulaceum* Mol. PAGE CO.: On rock along trail to summit of Stony Man Mt., alt. 3500-4000 ft., 570. The conspicuous julaceous branches are an aid in the recognition of this variety known only from Arizona, according to Grout (1932), but reported recently from Massachusetts by Hilferty (1959).

Lindbergia brachyptera (Mitt.) Kindb. PAGE CO.: On small tree trunk mixed with *Leucodon*, trail to summit of Stony Man Mt., alt. 3500-4000 ft., 3668; on trunk of *Betula lenta* in Elkwallow Picnic Grounds, alt. 2400 ft., 3679. (WYTHE).

Mnium cinclidioides Hüb. PAGE CO.: Partially immersed in water in Big Meadows Swamp, alt. 3500 ft., 3594. (NEW KENT).

Oreoweisia serrulata (Funck) DeNot. PAGE CO.: On rock outcrop along trail to Lewis Falls, alt. 2500 ft., 3601. WARREN CO.: Mixed with *Myurella sibirica* and *Amphidium mougeotii* on rock outcrop at base of Overall Run Falls, alt. 1500 ft., 2505. (FAIRFAX, GILES, LEE, and ROANOKE).

**Philonotis glaucescens* (Hornsch.) Par. GREENE CO.: Abundant on rock bluff of South River Falls, alt. 2000 ft., 3855. The occurrence of this southern species in Virginia marks its farthest known northern extension in the eastern United States.

Philonotis marchica (Brid.) Brid. ALBEMARLE CO.: On rock outcrop near water, trail to Jones Run Falls, alt. 1500-2500 ft., 2336. (CRAIG, GILES, ISLE OF WIGHT, PRINCE GEORGE, ROANOKE, SURRY, and YORK).

**Plagiothecium denticulatum* var. *tenellum* BSG. PAGE CO.: On rock near Crescent Rock Overlook, alt. 3500 ft., 740. This variety is best distinguished from the typical variety by its peristome, which has only one cilium, as compared with the usual 3 or sometimes 2 cilia present in the peristome of the var. *denticulatum*.

Platygyrium repens (Brid.) BSG. AUGUSTA CO.: On base of oak along trail to Riprap Shelter, alt. 2000-2500 ft., 2282, 2295. GREENE CO.: On trunk of birch, Lewis Mt., alt. 3400 ft., 972; on base of oak on Appalachian Trail near Ivy Creek Overlook, alt. 3000 ft., 2370, 2371. MADISON CO.: On tree trunk along Whiteoak Canyon Trail, alt. 3000-3500 ft., 792; on tree trunk

near Limberlost, alt. 3000 ft., 867; on base of oak along Cedar Run Trail, alt. 1500-3400 ft., 1886; on trunk of maple along trail to Dark Hollow Falls, alt. 2800-3400 ft., 1966; on trunk of red oak, Old Rag Mt., alt. 2000-3200 ft., 2395. PAGE Co.: On tree trunk along trail to summit of Stony Man Mt., alt. 3500-4000 ft., 601, 651; on rotten log near Crescent Rock Overlook, alt. 3500 ft., 732. RAPPAHANNOCK Co.: On base of red oak, Little Devils Stairs Trail, alt. 2000-2700 ft., 2513; on rock near Browntown Valley Overlook, alt. 3000 ft., 683; on rotting log on Appalachian Trail to Big Log Spring, alt. 2500 ft., 1797. ROCKINGHAM Co.: On trunk of ash near Baldface Mt. Overlook, alt. 3300 ft., 970. (GILES, PRINCESS ANNE, and SPOTSYLVANIA).

Pohlia elongata Hedw. PAGE Co.: On rock by creek near Big Meadows Swamp, alt. 3500 ft., 765. (GILES and SMYTH).

Pohlia pulchella (Hedw.) Lindb. MADISON Co.: On soil along Old Rag Fire Road, alt. 2000-3500 ft., 2410. (NORFOLK).

**Pterigynandrum filiforme* var. *minus* Lesq. & James. PAGE Co.: On rocks along Appalachian Trail below Crescent Rock Overlook, alt. 3500 ft., 3644, 3650. Although the var. *filiforme* has been reported for Giles Co., this is the first report of this small rupestrial form for Virginia.

**Rhacomitrium heterostichum* var. *affine* (Schleich.) Jens. PAGE Co.: On rock in dripping water at summit of Hawksbill Mt., alt. 4000 ft., 2257.

**Rhacomitrium heterostichum* var. *sudeticum* (Funck) Jones. MADISON Co.: On rock at summit of Old Rag Mt., alt. 3200 ft., 2407. With the addition of this variety and the var. *affine* there are now four varieties of this highly variable species reported for the state. The other two are var. *gracilescens* BSG, known from Page Co. in the Park, and the var. *ramulosum* (Lindb.) Jones, known from Giles Co.

Sphagnum capillaceum (Weiss) Schrank. PAGE Co.: On humus on rocks at summit of Hawksbill Mt., alt. 4000 ft., 2255. (CAROLINE, GREENSVILLE, KING AND QUEEN, NANSEMOND, PRINCESS ANNE, SOUTHAMPTON, and WARWICK).

Taxiphyllum geophilum (Aust.) Fl. GREENE Co.: In crevice of rock near South River Falls, alt. 2000-2900 ft., 3814, 3833. (BUCHANAN).

Thuidium pygmaeum BSG. GREENE Co.: On underside of overhanging limestone rock outcrop, South River Falls, alt. 2000-2900 ft., 3799. (BATH, GILES, and NELSON).

Tortella tortuosa (Hedw.) Limpr. GREENE Co.: In crevices of limestone rock outcrop dripping with water, South River Falls, alt. 2000-2900 ft., 3800. (No county designated).

Zygodon viridissimus (Dicks.) Br. PAGE Co.: On trunk of oak mixed with *Platygyrium repens*, *Pylaisia* sp. and *Leucodon* sp. along trail to summit of Hawksbill Mt., alt. 3600-4000 ft., 2230. (GILES, HIGHLAND, and SMYTH).

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NOTES ON OHIO BRYOPHYTES

RICHARD DEAN KELLOUGH[1]

A recent study of the bryoflora of Clinton County, southwestern Ohio (Kellough, 1960), presents additional information on the distribution of bryophytes in the state. Previously 331 moss species were credited to Ohio, with only 13 reports from Clinton Co. (Giesy, 1957). I have been unable to find any previous records of hepatics from Clinton Co. The 400 square miles of this agricultural county are covered by glacial soil deposited by three Pleistocene ice masses. The county has a variety of microhabitats from which 105 mosses and nine hepatics have been listed (Kellough, 1960).

Extensions in known range, especially in a northerly direction, were noted for several species, but the county does not differ greatly in bryophyte composition from the remainder of the state. Clinton Co. does not have a great diversity of microclimates but does have a variety of substrata with a wide range of hydrogen-ion concentrations. This has contributed to the occupation of the area by many species since Pleistocene times.

The bryophyte flora of Clinton Co. is composed for the most part of species widely distributed in the state. The exceptions are a few mosses which grow in rather unusual habitats and several that are known to be uncommon. Two of the mosses, *Bryum pendulum* (Hornsch.) Schimp. and *Weissia microstoma* (Hedw.) C. M., were previously unknown from Ohio. *Weissia microstoma* was discovered on clay soil in Clinton Co. It had been previously collected in Massachusetts, New Jersey, and possibly from Ohio. *Cirriphyllum boscii* (Schwaegr.) Grout is a characteristically south-

[1] 120 C St., Davis, Calif.

ern species reported rather frequently from Ohio and found by the author to be common on the soil of Clinton Co. *Bryum bicolor* Dicks. is more frequent southward and previous to this study was known from Ohio only from Athens Co.

Ohio is the southernmost limit for several species common in southeastern Canada and northeastern United States. Among these, *Orthotrichum sordidum* Lesq. & James, *Leskea nervosa* (Schwaegr.) Myr., and *Mnium punctatum* Hedw. may be noted from Clinton Co. Ohio seems to be the western limit for *Orthotrichum ohioense* Sull. & Lesq. *Bryum argenteum* Hedw. and *B. capillare* Hedw. are both world-wide weeds, but the latter is not nearly so common locally as might be expected. Most of the 114 bryophytes recorded by the author for Clinton Co. are typical species of eastern North America.

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RICCIA ALBIDA, A VALID SPECIES

Ronald L. McGregor and Bernadette Menhusen[1]

In 1845 Dr. Charles Wright made a small collection of a very interesting *Riccia* species in Texas which Sullivant, in 1853, named *Riccia albida* (*in herb.*). The exact location of Wright's collection is unknown, but from his movements in 1845 it may be presumed that the collection was made southwest of Austin and northwest of New Braunfels. The first description of *R. albida* was that of Austin (1869). Underwood (1884) repeated the description given by Austin but added nothing to it. The first careful description was given by Howe (1923). McAllister, Hoglund, and Whitehouse (1932) gave a brief description of the species and a photograph. Inasmuch as McAllister apparently was the first individual to collect the species since Wright, he was able to give its habitat as "calcareous rocks of the Edwards Plateau." Frye and Clark (1937) were unaware of McAllister, Hoglund, and Whitehouse's publication and essentially repeated the description given by Howe (*l.c.*) They did, however, make a statement, in a footnote, which threw some doubt on the validity of the species, as follows: "It

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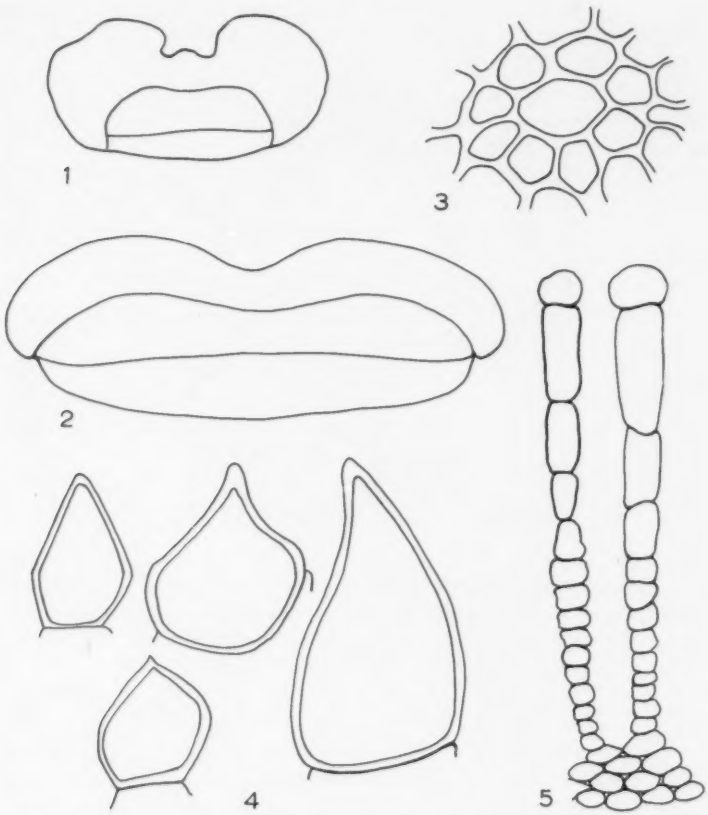
would be an interesting experiment to grow various species of *Riccia*, including *R. glauca*, *R. sorocarpa* and *R. donnellii* on a soil watered only with a saturated solution of lime. An incrustation of lime might affect the form and structure."

Underwood (1894) reported receiving a single plant of *R. albida* collected by Langlois in Louisiana. This is the only record of the species from outside the Edwards Pleateau of Texas, and as the specimen is apparently not extant, the occurrence in Louisiana is questionable. McAllister *et al.* (1932) gave the distribution as TEXAS: Uvalde, Kerr, and Real Co. A specimen at the New York Botanical Garden was collected by McAllister, in 1934, from 12 miles northwest of New Braunfels, Comal Co.

All material preserved as herbarium specimens has been very meager and immature and has not allowed an adequate description of this very interesting species. During the last two weeks of December 1957, the senior author was able to collect hundreds of specimens of *R. albida* from four stations on the Edwards Plateau. These form the basis of the following description:

Riccia albida Sull. Thalli medium-sized, 3-10 mm. long, mostly 1-4 times dichotomous, forming rosettes or irregularly gregarious, chalk-white and calcified, alveolate-reticulate or spongiose above both when living and when dried, the margins and sides white and somewhat spongiose; main segments oblong, cuneate-oblong, or subquadrate, 1 to 2.3 mm. wide; terminal segments quadrate, obtuse; margins rounded, minutely to prominently papillate; median sulcus acute to rounded, one-fourth to one-eighth the width of the thallus, persistent; scales minute, soon disappearing; transverse sections semiorbicular to subelliptic, 1.5-2.5 times as broad as high, 15-25 cells thick in median parts, the cells of 1-6 dorsal layers elongate, decolorate, and with calcified walls, air canals enlarged, pores 20-50 μ in diameter; cells of primary stratum of dorsal epidermis long-persistent, rounded-truncate, or often mammillate to apiculate, 20-40 μ broad, very variable in form. Dioicous; male plants smaller and narrower than the female, antheridial ostioles very slightly elevated; mature spores bronze-black, opaque, 80-102 (averaging 90) μ in maximum diameter, obscurely angled, rarely a little flattened, wing margin wanting, outer face with very low, inconspicuous, irregular wrinkles or pits but appearing smooth unless cleared, inner faces similar to outer but even less marked.

In all respects *R. albida* appears to be a most unusual but a perfectly valid species. In the collections made by the senior author, it was associated with *R. iodocheila*, *R. lamellosa*, *R. hirta*, and a species of *Fossombronia*. In all four stations the moss *Acaulon schimperianum* Sull. was present, together with juvenile plants of



Ricca albida. 1. Transverse section near apical end of thallus, × 110. 2. Transverse section of thallus, × 110. 3. Pore with surrounding cells, × 485. 4. Cells of primary epidermis, × 970. 5. Dorsal rows of cells with upper elongated calcified layers, × 485.

Pterigoneuron sp., *Weisia* sp., and soil algae of the genera *Nostoc, Gloeothece, Chroococcus, and Scytonema*. Though all sites were very rich in calcium, only *R. albida* was white. The incrustation of calcium is a regular characteristic of the species and appears when the sporeling is barely large enough to see with a 10× hand-lens. The incrustration occurs only on the dorsal layers of cells which surround the air chambers. Both the inner and outer walls of the cells have an even deposit of calcium which gives the layers a milk-white to pearl-white appearance. Such calcified cells do not bear chloroplasts. Removal of the layer of calcium with acid

causes the cells to collapse. It is thus extremely difficult to section this layer as it fragments when calcium is present and is completely collapsed when it is removed.

In culture *R. albida* grows well on a variety of soils as long as calcium is present. When grown on soils with much reduced calcium the calcified layers develop, but the plant soon dies. The senior author has grown *R. albida* to maturity in pots together with *R. beyrichiana, R. hirta, R. frostii, R. sorocarpa, R. dictyospora,* and *R. gougetiana.* In each case the species maintained their distinctive characteristics.

Though McAllister *et al.* (1932) reported *R. albida* as "growing on calcareous rocks of the Edwards Plateau," the senior author found it on light brown to black soils in open places between clumps of grass or on barren ground shaded by *Prosopis,* live oak, or large clumps of *Opuntia.* In each case the soil was shallow over surfacing limestone or had very fine flaky particles of calcareous material in the soil. Plants were common but widely scattered. Concentrations of the species were found on flood plain terraces along streams which arose in the Edwards Pleateau.

Specimens examined. TEXAS: COMAL Co., 12 mi. NW. of New Braunfels, black limestone soil of Edwards Plateau, Conn's Ranch, Nov. 23, 1934, *F. McAllister* (NY); BANDERA Co., 8 mi. W. of Tarpley, open grassy areas between live oaks, shallow soil over limestone, Dec. 26, 1957, *R. L. McGregor* 13806 (KANU); KINNEY Co., 4.6 mi. E. of Brackettville, shallow soil over limestone, shade of *Prosopis* and *Opuntia,* Dec. 25, 1957, *R. L. McGregor* 13799 (KANU); MEDINA Co., 17.8 mi. N. of Hondo, high flood plain terrace of Hondo Creek, bare soil between limestone rocks, Dec. 26, 1957, *R. L. McGregor* 13811 (KANU); UVALDE Co., 30 mi. NW. of Uvalde, Jeff McFitter's Ranch, Dec. 22, 1921, *F. McAllister* (NY); UVALDE Co., 8 mi. N. of Concan, Garner Park, flood plain of Frio River, bare soil between limestone rocks, Dec. 26, 1957, *R. L. McGregor* 13801 (KANU).

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VEGETATIVE PROPAGATION OF RICCIA RHENANA

RONALD L. MCGREGOR[1]

For several years I have been interested in the survival ability of *Riccia rhenana* Lorbeer in our area where some of the ponds become dry for long periods during drought. As *R. rhenana* is completely sterile and never produces spores, survival and multiplication appears to be vegetative in nature.

Beginning in the spring of 1954 I began observations on a few small ox-bow ponds in the Kansas River valley near Lawrence, Kansas. In May and June *R. rhenana* is found in abundance among cat-tails, sedges, rushes, and grasses in shallow water. In early April it multiplies rapidly by growth and division of the thalli. As summer approaches this activity decreases as the water temperature increases and the water level recedes by evaporation.

By mid-July the smaller of the ponds often will be without water. The *Riccia,* in its aquatic stage, will exist in shaded areas clinging to stems of aquatic vascular plants or lodged in debris. The thallus rapidly dies up to the growing apex which I have observed to remain alive for a maximum of 33 days at which time it began growth when placed in an aquatic environment.

Some of the thalli, however, become strand plants on mud and develop into the land form which is a typical rosette in organization with internal anatomy similar to that of strictly land species. These thalli develop into large rosettes or gregarious colonies, and as such they can withstand four to five weeks' desiccation. When the substrate dries to the point where death of the growing apices takes place, a little investigation will reveal thalli which have grown down into the cracks in the soil. On two occasions living thalli have been observed to remain alive in such an environment for a period of more than two months.

With the advent of rains and refilling of the reservoirs the growing apex of the submerged thalli begin a rapid growth and produce a characteristic aquatic stage thallus which will break away to continue development of the water stage. Thus *Riccia rhenana* can exist for at least three months out of the water environment. With autumn rains a rapid vegetative propagation again builds up the population.

The advent of winter causes the ponds to freeze and thaw many times during the season. Often the shallow areas freeze solid, and the thalli are repeatedly frozen in ice. This results in death of the thallus up to the growing apex. These apices have remained alive

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for more than five weeks while in ice. After being released by melting of ice the apices begin growth and continue until frozen in again.

By early spring the population consists of many small bits of thallus each with a small growing apex. These rapidly produce the large population observed in the spring and early summer.

The remarkable ability of this species to maintain itself in spite of long droughts is shared equally well by *Riccia fluitans* and *Ricciocarpus natans* in the same ponds. The latter, however, regularly produces spores but nevertheless is able to maintain itself vegetatively precisely as does *R. rhenana.*

During the study I have observed two methods by which *R. rhenana* and *R. fluitans* are distributed from pond to pond. On one occasion I discovered living thalli of *R. rhenana* clinging to the carapace of a large snapping turtle which was more than half a mile away from the nearest pond. A friend brought me a pin-tail duck which he had shot just before it was to land on the Kansas River; it had a fragment of *Riccia fluitans* thallus caught in a feather on its back at the base of the neck. In both cases the growing apex was alive.

FRULLANIA MAGELLANICA[1]

Lois Clark and Carol Palm[2]

Frullania magellanica (Spreng.) Web. & Nees *in* G.L. & N., Syn Hep.: 446. 1845; Steph., Sp. Hep. 4:664. 1911. *Jungermannia magellanica* Spreng., Ann. Wetter. Ges. 1:25. *Pl.* 4, *fig.* 10. 1809; Schwaegr., Hist. Musc. Hep. Prodr. 13. 1814; Web., Hist. Musc. Hep. Prodr. 22. 1815.—Plants medium in size, brown or reddish-brown, graceful, creeping on stones. Mature leafy shoot to 615 μ wide. Stems 6 cm. long, 34 μ in diameter, pinnate or bipinnate; branches 2-4 leaves apart on same side of stem. Leaves unequally bilobed. Mature dorsal lobes distant, contiguous or imbricate, erect-spreading, asymmetric, orbicular-ovate, 420-461 μ long (as measured from middle of insertion to apex), 420-568 μ wide, ventrally concave; apex obtuse or mucronate; margin entire to somewhat crenulate; dorsal margin crossing stem to 1/2 a stem-width beyond; dorsal base cordate or rounded; ventral base larger, cordate to auriculate, the auricle rounded to shortly lanceolate. Immature

[1] This work made possible by a grant from the Biological and Medical Research Fund of the State of Washington.

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leaves much like the mature ones but dorsal lobes smaller, less concave and more pointed. Mature saccate ventral lobes somewhat distant from stem, thus allowing room for the wide stylus, parallel with the stem or at a slight angle to it, wholly saccate; sac long helmet-shaped, 163-191 μ long, 71-99 μ wide, slightly constricted near flaring mouth, not or slightly extending beyond lower margin of dorsal lobe. Cells of stem leaves at apex and margin more or less isodiametric, 9-10 μ; walls thin; trigones small or wanting; cells of middle 10-12 by 18μ; walls somewhat thickened; trigones small or wanting; cells of base 13-18 by 15-24 μ; walls about 2.5 μ thick, in very old leaf auricles with walls quite thick; trigones small. Stylus large, about as large as the sac or slightly smaller, ovate, to somewhat triangular; apex rounded or slightly narrowed, about 142 μ long, and 10 μ wide at midpoint, from a short 2-celled stalk concealed in its basal fold; margin entire, cells 8 by 15 μ, walls thick. Mature leaf subtending branch larger than adjacent leaves, orbicular to wider than long, about 390 μ long by 533 μ wide, apex slightly concave, emarginate to rounded; margin entire; ventral base truncate to rounded; dorsal base cordate to auriculate; stylus leaf-like, about 10 μ wide by 76 μ long, its cells very thick-walled. First leaf of a branch 2 saccate lobes or an inner saccate and an outer explanate lobe, stylus present, leaf-like. Mature underleaf to 1.5 stem-width, subrotund, 284-319 μ long, 248-284 μ wide, bilobed to 1/8 leaf-length; margin entire or with suggestion of bluntly projecting shoulders on one or both sides, especially when young; immature underleaves smaller with deeper sinus. First underleaf about 142 μ long; branch 2-lobed, lobes unequal. Plants bisexual. Male inflorescence terminal on a short branch, close to or distant from the female inflorescence, roundish, sometimes with 1 or 2 bract-like leaves, at base with short stalk; male bracts 4-8, unequally bilobed, lobes strongly keeled; margins entire except for stylus on inner margin of ventral lobe; male bracteole narrowly elliptical, entire, apex 2-lobed, lobes acute; sinus extending 0.2-0.5 down, acute. Female inflorescence on short branch or on main stem. Female bracts larger than leaves, erect, unequally bilobed for 0.5-0.3 the length; dorsal lobe broadly lanceolate to subelliptical, acute, about 510 μ long by 383 μ wide; ventral lobe slightly shorter than the dorsal, acute, entire except for small stylus near base of inner margin; female bracteole united for 1/3-1/4 its length with both bracts, somewhat elliptical, 2-lobed for about 1/3 its length; margins entire; apices of lobes acute. Perianth about 1/2-emergent, 3-angled when young, approaching 5-angled when old owing to 2 blunt supplementary ridges arising near the middle of the perianth,

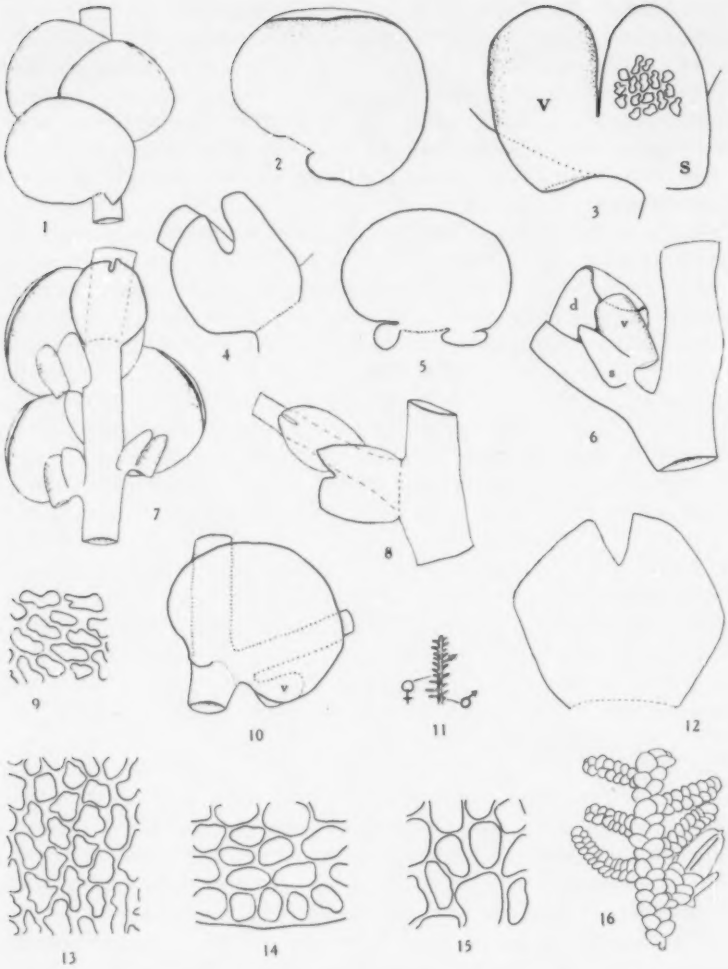

FIG. 1-16. *Frullania magellanica*. 1. Part of stem, dorsal view, × 35. 2. Dorsal leaf lobe, ventral view, × 58. 3. Ventral leaf lobe (*v*) and stylus (*s*), × 145. 4. First underleaf of branch, × 103. 5. Leaf subtending branch, × 42. 6. First leaf of branch (*d*, dorsal lobe; *v*, ventral lobe; *s*, stylus), × 58. 7. Part of stem, ventral view, × 35. 8. First underleaf of branch, × 58. 9. Cells of stylus of leaf subtending branch, × 267. 10. Leaf subtending branch (*v*, ventral lobe), × 42. 11. Plant, × 1. 12. Mature underleaf, × 100. 13. Cells of middle of underleaf, × 267. 14. Cells of auricle of leaf subtending a branch, × 267. 15. Cells of median base of leaf subtending a branch, × 267. 16. Part of plant, × 7.

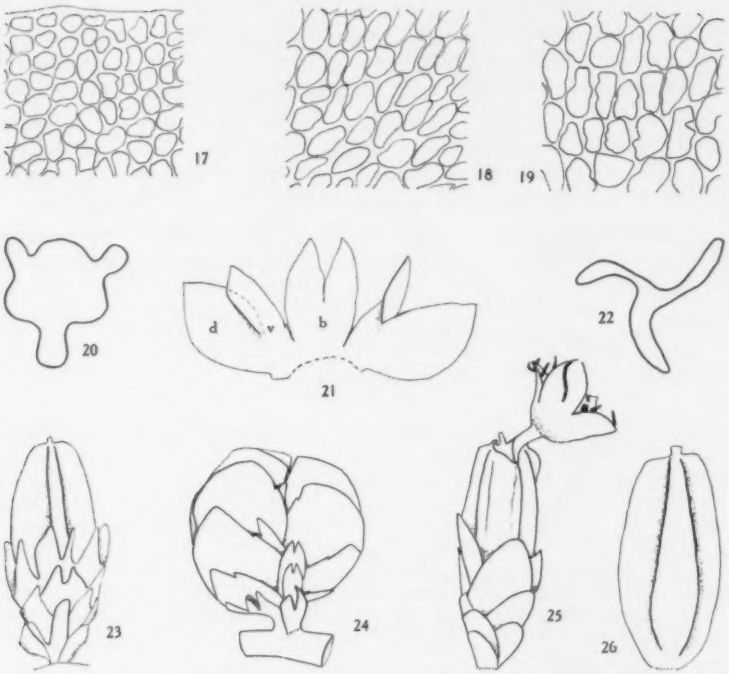

FIG. 17-26. *Frullania magellanica*. 17. Cells at tip of dorsal leaf lobe, × 267. 18. Cells of middle of dorsal leaf lobe, × 267. 19. Cells near ventral base of dorsal leaf lobe, × 267. 20. Cross-section below middle of mature perianth, × 34. 21. Involucre (*d*, dorsal lobe of bract; *v*, ventral lobe of bract; *b*, bracteole), × 48. 22. Cross-section of young perianth, × 33. 23. Female inflorescence, × 17. 24. Male inflorescence, × 151. 25 Female inflorescence with sporophyte, × 17. 26. Young perianth, × 20. Drawings by Carol Palm from *Kühnemann* 4890 and 4893).

1.27-1.62 mm. long, 532-710 μ wide, rounded or truncate to beak, smooth; beak about 35 μ wide and 71 μ long, inner surface papillate. Sporophyte with short seta; cells of seta haphazard; elaters reddish, unispiral, trumpet-shaped.

HABITAT: On trees.

TYPE: On *Berberis illicifolia* and *Wintera aromatica* along Strait in Cape Horn region (*Forster*).

RANGE: Patagonia, Fuegia, Argentina, antarctic regions (common).

SPECIMENS EXAMINED: ARGENTINA, State of Chubut, Lake Menéndez (*Kühnemann* 4890); Torrecillas, a village in the vicinity of Lake Menéndez (*Kühnemann* 4893).

We have not seen the type, but as described the plant resembles *Frullania stipatiloba* Steph. in the following respects: Both are

bisexual, with the female inflorescence on the main stem or a main branch. The two have similar perianths having five keels of which two are supplementary, arising near the middle of the perianth. However, they differ in that in *F. stipatiloba* the stylus is only two or three cells wide and is composed of only about 11 cells, is much smaller than the ventral lobe, its apex is only one cell wide, and its cell walls are not thickened at base; the first underleaf of a branch is not lobed at apex; the small saccate ventral lobe is far from the stem, at a wide angle. The two species seem distinct insofar as the differences now known are concerned.

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RECENT LITERATURE ON LICHENS—36[1]

WILLIAM L. CULBERSON[2]

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GLANC, K. [&] Z. TOBOLEWSKI. Porosty Bieszczadów zachodnich. [Lichens of the western Bieszczady.] Poznańskie Towarzystwo Prazyjaciół Nauk, Wydział Matematyczno-Przyrodniczý, Prace Komisji Biol. 21(Zeszyt 4) : 1-108. 8 fig. 5 pl. 2 tab. 1 folding map. 1960. [309 spp. Data on altitudinal distribution. Keys in Polish to Caliciaceae, *Lecanora* (Eulecanora) and *Caloplaca*. English summary.]

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[1] The names of new taxa from the Americas are marked with an asterisk (*).

[2] Dept. of Botany, Duke University, Durham, N. C.

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Lądek Zdrój, Stronie Śląskie. The influence of small towns on the lichen vegetation. Part V. The valley of Kłodzko—Kłodzko, Kudowa Zdrój, Duszniki Zdrój, Polonica Zdrój, Lądek Zdrój, Stronie Śląskie. Ann. Univ. Mariae Curie-Skłodowska [Lublin] Sect. C. 11(2): 25-50. 1 tab. 1956. [62 spp. ". . . the reason for an impoverishment of the lichen flora in some small . . . [towns is] . . . not gasses produced by coal combustion, but local factors which decrease the humidity of the air and substratum."—English summary.]

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NEWS AND NOTES

Mr. WILLIAM L. DIX has deposited his lichen collections of some 1200 specimens in Duke University Herbarium. The *Cladoniae* of Pennsylvania are especially well represented, and most of the specimens were studied by the late Alexander W. Evans.

The reader of these columns who would like a taste of science fiction close to home is referred to his newsstand where 35 cents will buy John Wyndham's *Trouble With Lichen* (Ballantine Books, New York, 1960). A lichen-derived elixir that extends man's life expectancy by hundreds of years is isolated by a British chemist from a rare, ultra-localized Manchurian species. A consideration of the problem of selecting the few people in the world who can be offered the treatment takes the reader on an amusing romp through a far-fetched cryptogamic botany with time out for satirical sketches of contemporary man and his complex society.

Dr. HERMANN REIMERS, noted German bryologist, died on May 18.

The annual meeting of the American Bryological Society will be held in conjunction with the AIBS meetings at Purdue University, Lafayette, Indiana. For details concerning the foray, sessions, and bryologists' breakfast, write Mrs. NOE HIGINBOTHAM, 105 S. Spring St., Pullman, Wash.

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Beginning January 1, 1939, this Exchange has been operated under the same rules as The Moss Exchange. Privileges are available only to members of the American Bryological Society who have paid annual dues of 25c to MR. HARRY WILLIAMS, Millbrook, Ont., Canada. Only fully determined specimens in packets with complete data will be accepted. It is suggested that there be at least five packets of each species with an extra which will be forwarded to the Curator of Hepatics for the American Bryological Society Hepatic Herbarium. All material for determination should be sent to the Curator of Hepatics, DR. MARGARET FULFORD, Department of Botany, University of Cincinnati, Cincinnati, Ohio.

THE MOSS EXCHANGE

As announced in THE BRYOLOGIST **38**: 100, Sept.-Oct., 1935, there is now an exchange for mosses. This exchange is available to members of the American Bryological Society upon payment of annual dues of 25c to DR. RONALD A. PURSELL, School of Forestry, University of Pennsylvania, Mont Alto Branch, Mont Alto, Pa. Only fully identified specimens in packets with complete data on them should be sent in. It is suggested that there be five or more packets of each species.

These two exchanges offer an excellent opportunity for A.B.S. members to build up their own herbaria of choice, well-labelled specimens.